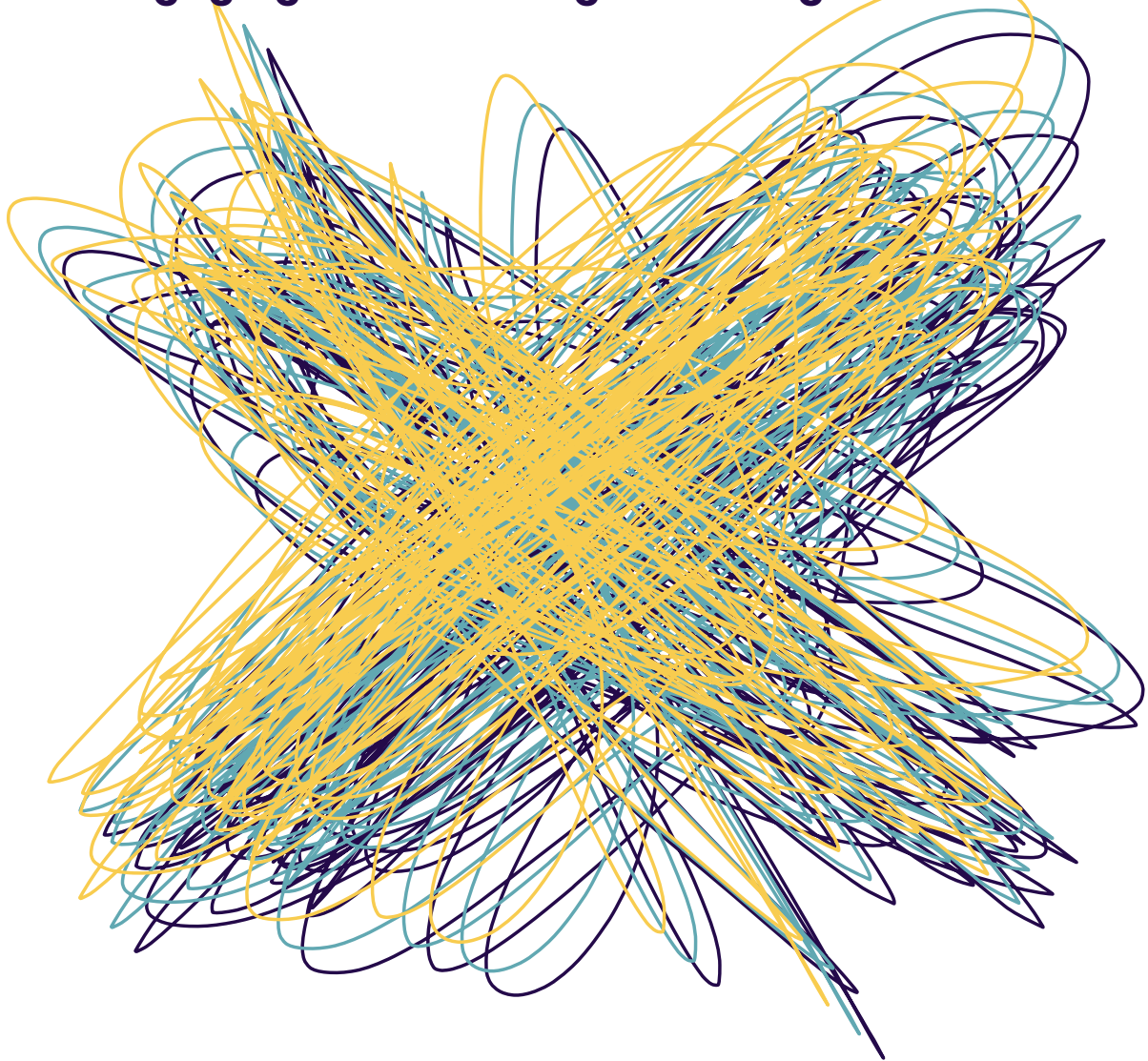


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DRS LEARNxDESIGN 2021

Engaging with Challenges in Design Education



**6th International Conference
for Design Education Researchers**

24–26 September 2021
Jinan | China

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in the Year
of the Ox
牛年大吉

Designed by: 张东景 Zhang Dongjing

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10th Anniversary of the International Conference for Design Education Researchers

DRS LEARNxDESIGN 2021

国际设计教育学者大会10周年

Lusheng Pan

https://doi.org/10.21606/drs_lxd2021.329

As the DRS LEARNxDESIGN General Chair, it is my hope, that in the next decade, the future conference organising committee members will look at back this 10th Anniversary of the International Conference for Design Education Researchers volume of conference proceedings with an affection. The volume reflects the dedicated work of close to 500 individuals who in various ways contributed to production of these proceedings as authors, peer reviewers, planners, volunteers, editors, managers, technicians, or designers. The 10th Anniversary of the International Conference for Design Education Researchers reflects incredible determination of those who came before us who initiated and establish conference as the key platform for the Design Research Society's Education SIG to disseminate research related to Design Education.

I would like to thank to the Design Research Society to entrust Shandong University of Art & Design to host this key International Conference for Design Education Researchers. This has been a first time a Chinese University has hosted a key International Design Education conference of this size. I would especially thank to the International Academic Organizing Committee members Erik, Liv, Yang and Naz, who contributed their enthusiasm and expertise to make the event a wonderful success. Great gratitude is to be given to staff from OsloMet, UDD, and METU who have generously set up the specific Zoom links for the parallel sessions and thus made it possible to translate these sessions.

By embarking on hosting the 10th Anniversary of the International Conference for Design Education Researchers, Shandong University of Art & Design's aim was to make a significant contribution to national and international research on design education. To achieve this aim Shandong University of Art & Design has made a number of important commitments. One of these was to initiate a new **Design Education Research Centre**. The university has made a substantial planning to inaugurate the centre shortly after the conference.

To bridge the persistent Global South and North divide as the host, Shandong University of Art & Design, has widen the International Scientific Programme Committee memberships.

To enable recent graduates to provide a significant input into what should be covered at the conference which focuses on how they should be educated we have made call for the emerging scholars.

Our focus is to deliver a high-quality academic conference. Thus, the focus was on the quality rather than the quantity. We have supported a rigorous peer review process to include the high selected quality academic papers in the conference proceedings

Drawing is a fundamental language for designers. It supports to analyse, organise, communicate, reflect, negotiate, persuade, explain, discuss, and present design concepts, products, experiences, and services. It is used throughout New Product Development process, from strategic initiation to its implementation. Thus, I was supportive of the International Academic Organising Committee proposal to introduce a Track which will challenge authors to use visualisation methods to communicate their papers in a visual form.

In 2016 the Chinese Ministry of Education has included the Design discipline to the "Special Catalogue of General Colleges and Universities" with aim to scale up the design education. Since 2016, more than **2000 of institutions** have been delivering design programmes. Every year more than **540 000** students enrolled into Design programmes. The number of **students studying design and related majors** in the school now **exceeds 2 million**. The design discipline has become the most prominent one in more than 140 first-level disciplines



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and more than 90 undergraduate majors in China.

I would like to thank to the local committee in Shandong University of Art & Design. Thanks to the design group who was responsible for designing the beautiful gifts and certificates of the top submissions. Also, I want to say thank you to the cultural event group. They provided the delegates with cultural feasts. I really appreciate support from the assistants who recording the sessions. Great gratitude should be given to our interpreters, who help us to enjoy the conference with their efforts.

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Professor Dr. Lusheng PAN, Vice-Chair of China Federation of Literary and Art Circles, Chair of China Folk Literature and Art Association, President of Shandong University of Art & Design, founder of Oriental Folk Art Museum, senior expert and leading talent in national philosophy and social sciences, enjoying special government allowance of the State Council. He also serves as the main leader of the Teaching Steering Committee of design specialty in Colleges & universities of Ministry of Education. His research focuses on design education and folk art. He has presided more than 30 national research programs, undertaken over 20 major national & provincial social service projects, published more than 30 books and over 200 academic papers.

Jinan 2021: Engaging with Challenges in Design Education

6th International Conference for Design Education Researchers: DRS Learn X Design 2021

Erik Bohemia, Liv Merete Nielsen, Naz A.G.Z. Börekçi and Yang Zhang
https://doi.org/10.21606/drs_lxd2021.330

10th Anniversary of the DRS Learn X Design Conference Series

The year 2021 has been particularly special for the DRS Learn X Design (LxD 2021)¹ organising teams. The conference series marked the 10th anniversary since the first event was held in Paris in 2011 (Bohemia et al., 2011)², see the reflection on page 50. Since then, the conferences have been organised biannually. The DRS/CUMULUS 2nd International Conference for Design Education Researchers was held in Oslo in 2013, on the theme of *Design Learning for Tomorrow – Design Education from Kindergarten to PhD* (Lloyd & Bohemia, 2013; Nielsen et al., 2015; Reitan et al., 2013)³, see the reflection on page 45. The DRS/CUMULUS/Design-Ed Learn X Design 3rd International Conference for Design Education Researchers was held in Chicago in 2015, on the theme of *Education and Design to Enlighten a Citizenry* (VandeZande et al., 2015)⁴, see the reflection on page 38. The DRS Learn X Design 4th International Conference for Design Education Researchers was held in London in 2017, on the theme of *The Allure of the Digital and Beyond* (Pritchard & Lambert, 2017)⁵, see the reflection 35. The DRS Learn X Design 5th International Conference for Design Education Researchers was held in Ankara in 2019, on the theme of *Insider Knowledge* (Börekçi et al., 2019)⁶, see the reflection on page 30. The theme for the 6th International Conference for Design Education Researchers hosted by the Shandong University of Art & Design was *Engaging with Challenges in Design Education* (Bohemia et al., 2021). The general 2021 conference theme reflected the unprecedented changes which took place in design education around the world since the first event was held in Paris a decade ago. For example, in China since 2016, more than 2000 of institutions have been delivering design programmes. Every year, also in China alone, more than **540 000** students enrol into Design programmes. And the number of **students studying design and related majors** in the Chinese schools now **exceeds 2 million**. The design discipline has become the most prominent one in more than 140 first-level disciplines and more than 90 undergraduate majors in China. China's growth of design programmes and design student graduates at universities is shifting the very foundation of how design is taught (Pan, 2021). In addition, the Design is being taken up increasingly by other disciplines (Bravo & Bohemia, 2021) and being incorporated into general education (Lutnæs, 2019) which requires us to reconceptualise the design education and its purposes (Bravo & Bohemia, 2020; Lloyd, 2011). This echoes advocacy by scholars such as Anita Cross (1984), Buchanan (2000), and Nielsen and Brønne (2013) for design to become part of the general education.

At the time when the general conference theme was proposed, Covid-19 which forced the most rapid and radical changes on design education, was not yet on horizon (see Figure 1). However, as the education has been rapidly transformed due to the Covid-19 pandemic that has affected the entire world, the general theme

¹ <https://dl.designresearchsociety.org/drs2021-learnxdesign/>

² <https://dl.designresearchsociety.org/drs2011-learnxdesign/>

³ <https://dl.designresearchsociety.org/drs2013-learnxdesign/>

⁴ <https://dl.designresearchsociety.org/drs2015-learnxdesign/>

⁵ <https://dl.designresearchsociety.org/drs2017-learnxdesign/>

⁶ <https://dl.designresearchsociety.org/drs2019-learnxdesign/>



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of the conference indivertibly became a fitting theme.



Figure 1. SUAD proposed to host the 2021 DRS Learn X Design conference in 2019. On the right, students practicing a performance routine at one of the SUAD theatres. The plan was to introduce conference participants to different cultural activities.

Note: The conference visual identity evolved over the time

The DRS Learn X Design 2021, 6th International Conference for Design Education Researchers took place online between 24–26 September 2021. It was hosted by Shandong University of Art & Design (SUAD) in Jinan, China. During this online international conference, the participants reflected on the ongoing challenges which have affected their practices. The process of sharing different perspectives with the international design education community members facilitated collective learning. The challenges that design educators experienced were reflected in the conference tracks, such as managing design education in times of crisis; and those related to ethics and our personal, societal and educational circumstances.

Submissions

Altogether 338 authors from 39 counties contributed 168 submissions as full research papers, case studies, visual papers or workshop proposals. The case studies and visual papers submission categories were introduced for the first time in this conference. The idea for the visual papers' category came from the Engineering and Product Design Education (E&PDE) conference which introduced this submission category at its 2018 event (Childs et al., 2018). The idea for the case studies was take from the 2019 Academy for Design Innovation international conference (Bohemia et al., 2019).

After a round of double-blind peer review process, which was supported by 219 members of the International Scientific Panel⁷, 50 (30%) submissions were accepted, 56 (34%) submissions were provisionally accepted⁸ pending satisfactory further peer reviews managed by the track chairs, and 58 (35%) submissions were rejected. This was followed by the subsequent peer review process involving the track chairs and co-chairs. The outcome of this final process was the inclusion of 91 submissions, which were scheduled in the conference programme and included for publication in the proceedings. The overall acceptance/rejection rate across the four categories was 46% (see Table 1), which is on par with the general DRS biennial international conferences (Boess et al., 2020).

⁷ Please see the full list on page ii.

⁸ If both peer reviewers indicated that a submission required a major revision then the submission was rejected outright.

Table 1. Submissions received for the 6th International Conference for Design Education Researchers: DRS Learn X Design 2021

	Received	Accepted	Rejected
Aggregate	168	91 (54%)	46%
Research Papers	103	53 (51%)	49%
Case Studies	39	24 (61%)	39%
Workshop	19	11 (7%)	58%
Visual Papers	7	3 (4%)	43%

Laying Out the Track Themes

With the aim of living up to the expectations of the 10th anniversary conference, one of the major concerns of the organisers was to articulate its relevance and appeal to attract diverse international design research community. The tracks facilitated achieving this goal. The tracks, by defining the conference scope by defining the subject matter and the extent to which the topics are explored, are the backbone of a conference. The tracks overview the existing pathways, determine new ones for research in an area, and set up the community for the conference. With its tracks, a conference can draw attention to the significance of a discipline and address the members of its community.

One of the particularities for the organization of this conference was the openness that the organisers strived to achieve, with voice given to a wide group of international scholars. The conference track themes were constructed altogether with a motivated group of international scholars and colleagues leading the process as track chairs and co-chairs. The track chairs from diverse backgrounds were invited to propose the themes guided by their specific research. Thus, the LxD 2021 tracks' scope diverted from traditional design education conferences which focus is explicitly on educational topics such as assessment or student group work. Instead, the LxD 2021 tracks themes were guided by specific tracks' chairs research areas, like how problems framing limits the potential solutions, and then related this area to education.

As the International Academic Organising Committee, we were very excited to be working together in this process. With the aim of making this process beneficial beyond experienced researchers, it was decided to give an opportunity to early career researchers in chairing a track for this conference. A call was made in August 2020, titled *Fishing for the Big Idea*. This is how the track *Futures of Design Education* was incorporated into the conference, with four early career researchers leading the process (see Figure 2, and Volume 4, on page 854).



Figure 2. Fishing for THE BIG IDEA™; The team of the early career researchers, the School of Small Fish, who initially proposed the theme: Bauhaus is Dead!

A total of 44 track chairs and co-chairs⁹ from 14 countries (Australia, Baltimore County, Brazil, Canada, Chile, China, Colombia, Denmark, Finland, Germany, India, Netherlands, Norway, Sweden, Turkey, UK, USA) worked together and in parallel, in bringing their own approaches and points of view, with topics that supported and complemented one another, and allow the germination of new discussions in the area. The wide geographical distribution required synchronisation among all which was facilitated by regular meetings distributed into an extending timetable, and long collaborative working hours. Many meetings were held online, with the altruism of the track chairs who were in different parts of the world (see Figure 7). Despite the challenges, these meetings also brought the benefits of including diverse perspectives which led to new ideas.



Figure 3. Regular meeting of track chairs and co-chairs provided opportunity to shape the conference scope

Share YOUR Passion

« Welcome & Review of DAY 1: Erik
Reflections on DAY 1 | **Moderators** » Erik + Liv | 40”
-- kick off with Naz, then Roland, then Andrés, then Janne, and so on... --

Break

18.15 « Outline the Conference Aims and Planning Activities and the vision for the International Scientific Committee (ISC) members’ roles to support the event development » **Erik**

Break

19.15 « Q&A
19.45 « Sum-up & END » **Liv**
20.00 Online Day 2 symposium closed

Figure 4. Share your Passion opening session for the Articulation of Alternate Futures symposium, which was held in September 2020, provided the track chairs with opportunity to know each other’s interests

⁹ Track chairs and co-chairs are listed under the heading *International Scientific Panel* on page i.

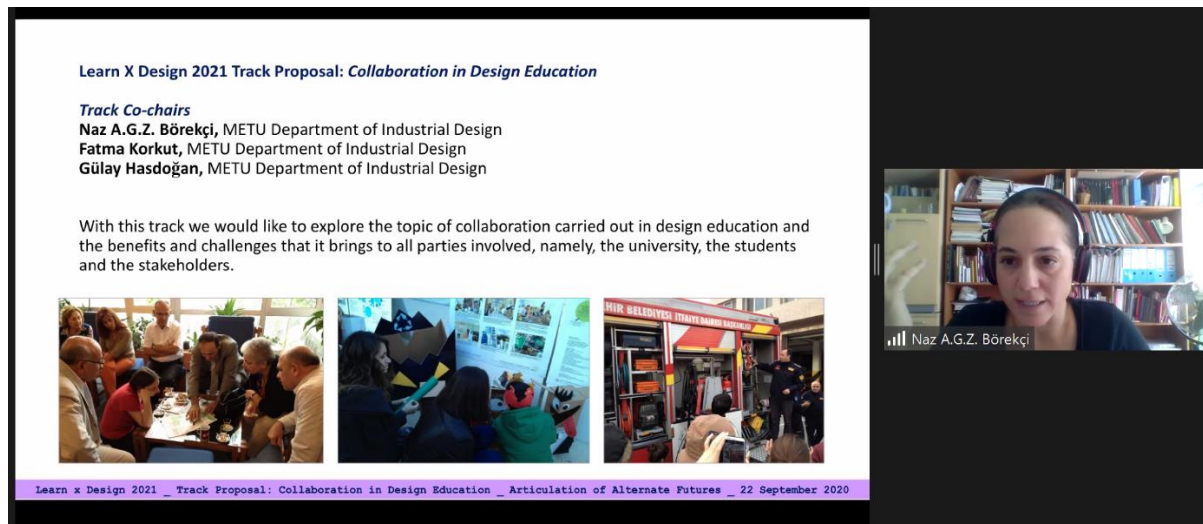


Figure 5. Naz A.G.Z. Börekçi outlining a track proposal titled 'Collaboration in Design Education' at during the 'Articulation of Alternate Futures' symposium which was held in September 2020.



Figure 6. On the left, Liv Merete Nielsen introduced Úrsula Bravo who proposed the track titled 'Design Thinking to Improve Creative Problem-solving' and on the right, Katja Thoring outlined proposal for the track titled 'Design Learning Spaces' during the 'Articulation of Alternate Futures' symposium which was held in September 2020.

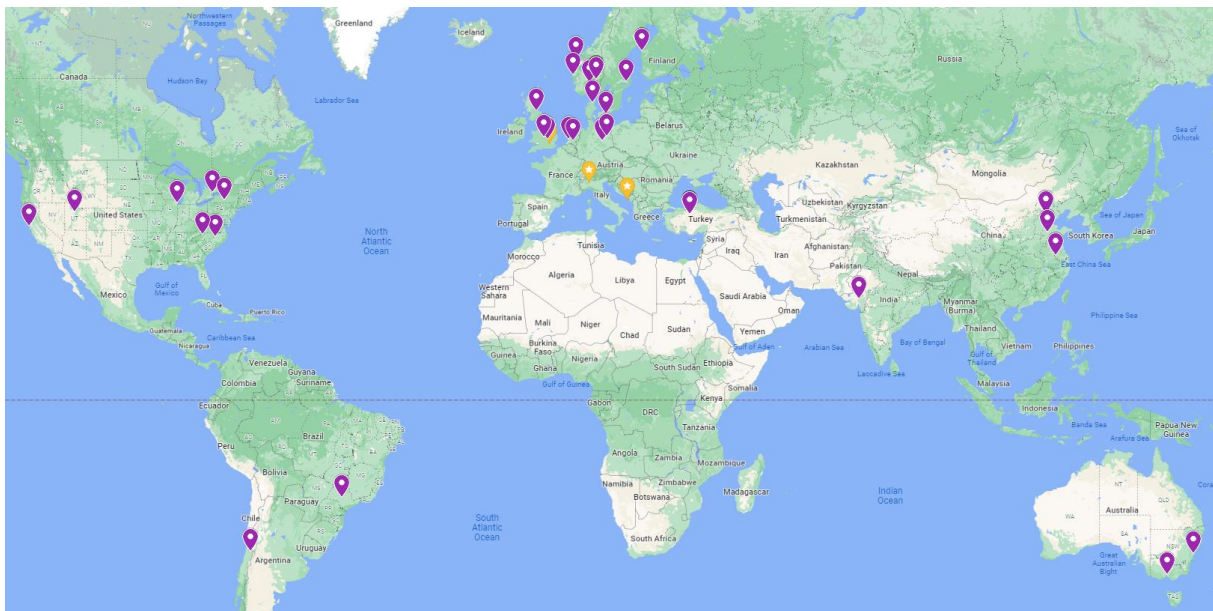


Figure 7. The geographical location of the LxD 2021 Track chairs and co-chairs

The 10-year anniversary conference programme and the four-volume conference proceedings have been organised within the 10 track themes managed by the track chairs with support from their co-chairs (see Table 2).

Table 2. List of Tracks and Submission Categories

Track Nº	Track Title	Submission Types			
		Full Research Papers	Case Studies	Workshops	Visual-Papers
Track 01	Design Thinking to Improve Creative Problem-solving	o	o	o	
Track 02	Empowering Critical Design Literacy	o	o	o	
Track 03	Alternative Problem Framing in Design Education	o	o	o	o
Track 04	Collaboration in Design Education	o	o	o	
Track 05	Co-creation of Interdisciplinary Design Educations	o	o		
Track 06	Learning Through Materiality and Making	o	o		o
Track 07	Sketching & Drawing Education and Knowledge	o	o	o	o
Track 08	Design Learning Environments	o	o	o	o
Track 09	Futures of Design Education	o	o	o	o
Track 10	Design Educators as Change Agents	o	o	o	

The track titled **Design Thinking to Improve Creative Problem-solving** chaired by Úrsula Bravo and co-chaired by Catalina Cortés, Jeannette LaFors, Andrés Téllez and Natalia Allende asked scholars to consider the challenges of taking design-based approaches those who do not intent to be trained as designers such as children, youth, teachers, and leaders in schools, universities, and other educational contexts (Bravo et al., 2021), see the track's introduction on page 59.

The **Empowering Critical Design Literacy** track chaired by Eva Lutnæs and cochaired by Karen Brænne, Siri Homlong, Hanna Hofverberg, Ingvill Gjerdrum Maus, Laila Belinda Fauske and Janne Beate Reitan aimed to explore the current educational practices, academic discourses and implications of design education empowering for critical design literacy (Lutnæs et al., 2021), see the track's introduction on page 222.

The next track titled **Alternative Problem Framing in Design Education**; chaired by Lesley-Ann Noel, and co-chaired by Renata Marques Leitão, Hannah Korsmeyer, Sucharita Beniwal, and Woodrow W. Winchester III, was asking scholars to consider how we might move design education away from problems, pain and othering (Holliday et al., 2010) towards positive models of framing challenges such as joy, desires, utopia and other positive or alternative re-frames (Noel et al., 2021), see the track's introduction on page 277.

The following track **Collaboration in Design Education** chaired by Naz A.G.Z. Börekçi and co-chaired by Fatma Korkut and Gülay Hasdoğan intention was to explore the benefits and challenges of collaboration in design education. For example, the submissions tackled issues related managing collaborations and strategies which facilitate maintenance and commitments of the parties to support design education (Börekçi, Korkut, & Hasdoğan, 2021), see the track's introduction on page 322.

The **Co-creation of Interdisciplinary Design Educations** track which was chaired by Arild Berg and co-chaired by Camilla Groth, Fausto Medola and Kate Sellen, focus was on the challenges related to co-creation practices when disciplinary world views 'crash' and what the implications of these are for design education (Berg et al., 2021), see the track's introduction on page 476.

The **Learning Through Materiality and Making** track which was chaired by Juha Hartvik and co-chaired by Mia Porko-Hudd and Ingvild Digranes was informed by the Scandinavian educational practices which aimed to provide children and young people an opportunity to process materials in order to gain experience, knowledge and learning that can be useful at different stages of life, in study, professional and leisure activities (Hartvik et al., 2021), see the track's introduction on page 604.

The **Sketching and Drawing Education and Knowledge** track which inspired the new submissions Visual Papers category was chaired by Bryan F. Howell and co-chaired by Jan Willem Hoftijzer, Mauricio Novoa Muñoz, Mark Sypesteyn, and Rik de Reuver focused was on research that reveals insights into how and why sketching and visual knowledge is reflected in education (Howell et al., 2021), see the track's introduction on page 626.

The **Design Learning Environments: Exploring the Role of Physical, Virtual, and Hybrid Spaces for Design Education** chaired by Katja Thoring and co-chaired by Nicole Lotz and Linda Keane provided a rich forum for the scholars explore how the physical and digital spatial environments of educational institutions can be designed in order to better facilitate learning (Thoring et al., 2021), see the track's introduction on page 687.

The track titled **Futures of Design Education: Beyond Time & Space** which was chaired by Yashar Kardar and

co-chaired by Lilyana Yazirlioğlu, Ayşegül Özçelik, and Sarper Seydioglu was based on recent graduates' experiences. The track asked the scholars to venture beyond the 'studio' to explore possibilities of new design education models conscious of members' social dynamics, identities, communities, and their role in enabling new education models which are more inclusive, personalised, and sustainable (Kardar et al., 2021), see the track's introduction on page 856.

The final track titled **Design Educators as Change Agents** which was chaired by Yang Zhang and co-chaired by Xiang Xia and Ziyuan Wang. The track's broad theme focused on design educators as change agents of design education (Xia et al., 2021), see the track's introduction on page 920.

The four submission category types

In addition to the ten tracks, the prospective authors were able to select one of these four submission categories:

- Research Papers
- Case Studies
- Visual Papers
- Workshop Proposals

The full **research papers** submissions were between 3500 and 6000 words in length. The **case studies** provided a platform for sharing a reflective account of a project(s). The case studies submissions were between 1500 and 3000 words in length. The **workshop proposals** provided an opportunity for scholars to explore new and emerging practices and research topics, facilitate debates, gather data, and test on-going research. They enabled practitioners to showcase their work in collaboration with design researchers. The workshop proposal submission were no more than 1500 words. The **visual papers** allowed scholars to use sketched images to communicate the primary information while text plays a supporting role. The visual papers needed to contribute new knowledge.

Preparatory Events

Two international events supported the main conference and marked certain milestones in the preparations. The first event was titled *Articulations for Alternate Futures*. It was an open symposium that took place one year prior to the conference, on 22–23 September 2020. The *Articulations for Alternate Futures* symposium invited prospective conference track chairs to introduce their main themes. The purpose was to articulate potential track themes and then further develop them in relation to each other, thus making sure that the themes complemented one another rather than compete. How the calls could be made or improved were also discussed to make sure the call for submissions would be open and addressing a wide range of academic, practical and research interests. The symposium was open to the participation of an extended audience, who were interested in the conference topic and would consider contributing. Altogether, over 110 participants have joined the two-day online symposium. Based on the discussions, the tracks were reorganised, merged, shuffled and reformed until the call for submissions was made in February 2021.



Figure 8. Naz A.G.Z. Börekçi is outlining programme for the Articulation of Alternate Futures symposium, which was held in September 2020.

The second supporting event was the *Explorations of Alternate Futures* symposium, held on 10–11 May 2021, where track chairs and organisers came together to rehearse the programme and the setting for a more inclusive and fulfilling online conference experience. This two-day symposium was attended by around 90 participants.

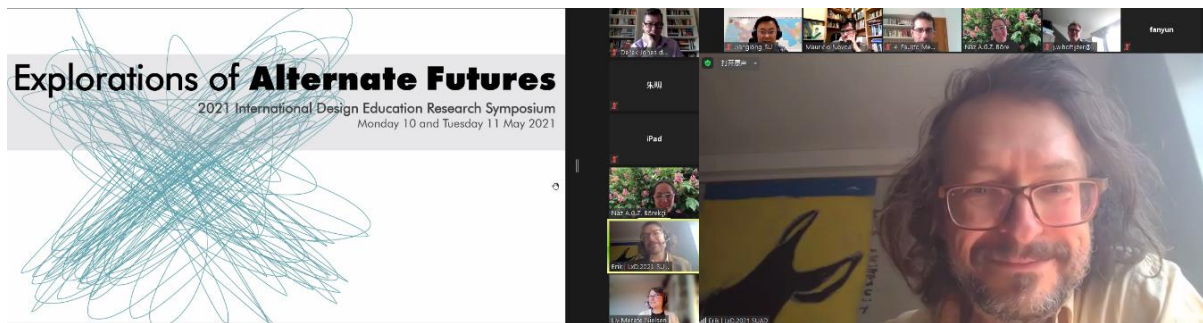


Figure 9. *Exploration of Alternate Futures* symposium which was used to prototype the online conference delivery

The online symposium held a year ahead of the conference helped the organisers to prototype the September 2021 conference and to identify which elements should be kept and which needed to be discarded. For example, the online parallel sessions were envisaged to take place in the breakup rooms, thus simplifying how delegates might enter the conference as they needed only one online meeting link. However, the online Zoom platform allowed only one interpretation channel to and from Chinese across all the breakup rooms. Thus, subsequent parallel sessions had dedicated meeting links. The timing and overall rhythm of the session delivery, social events and regular breaks were also tested. On the other hand, demonstration of the traditional Baduanjin stretching exercise by Master Ms. Feng Yujuan during the breaks was one of the highlights of this event. The event participants were introduced to eight Baduanjin basic steps. Fatma Korkut, 2019 LxD co-chair, stated that:

In general, I think the mood was perfect; people felt engaged and motivated. Geographical and institutional diversity was high. Thematic diversity was not that high, in my opinion. Perhaps some tracks intersect heavily around design thinking and design literacy. I felt excited about mini-exhibitions concerning visual design thinking (Bryan), and data-driven design (Roland). The presentation by young researchers was terrific; I listened to it with tongue in cheek :) We should have more student presence in this conference series. Plus, we need to encourage more visual events.

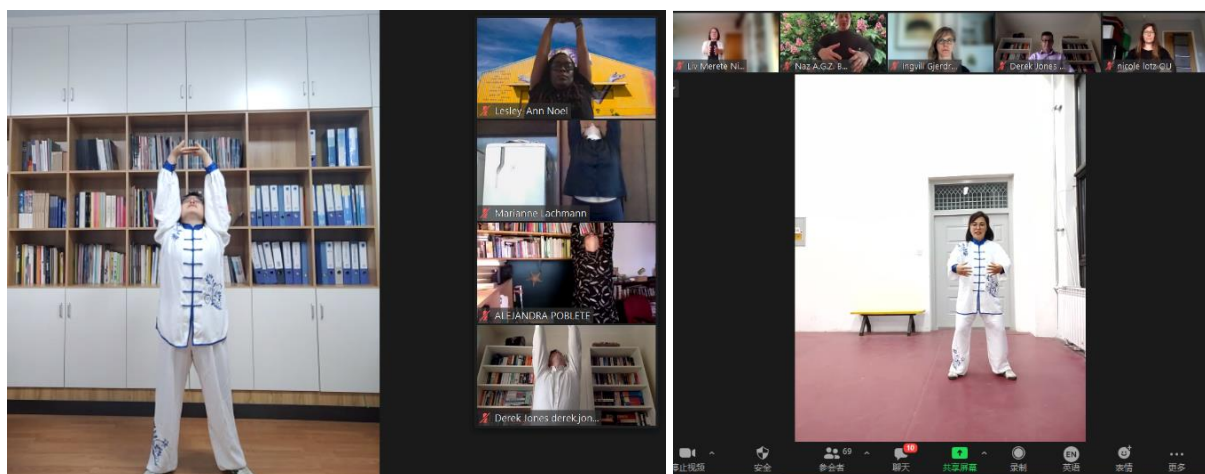


Figure 10. Master Ms. Feng Yujuan demonstrated the traditional stretching exercise: Baduanjin

Derek Jones, the DRS Design Education SIG convener, described the LxD 2021 planning process as

...inverting the normal conference procedure. Instead of a closed, small committee (that gets larger), it will be a wider, more open and inclusive community of organising contributors from the start. Instead of waiting to see what papers might be received and how to organise their review, it will make the

contribution process an integral part of the conference process, again, from the very start. It is this change in process that is particularly exciting and one that is potentially a better template for academic quality.

Derek perceived that the adopted conference planning and organising provided the following benefits:

Firstly, it avoids 'track isolation', where track chairs are responsible for everything as individuals - almost as mini conferences in their own right. Whilst this can work well in some subjects, the LxD 2021 proposal was to avoid such separation and isolation. This has already begun with this first symposium, where negotiation and discussion of subjects and themes between track chairs was in evidence, exploring domain overlaps and synergies. This will continue through the online platform.

Secondly, it shares knowledge between track chairs and subject domains which assists with the work and effort involved in being a track chair. Already, the sharing that took place in the first symposium indicates that contributors are keen to assist with this and with the best of intentions - to make each track as academically competent as possible.

Thirdly, it builds community. This was enabled right from the introduction through the setting, the tone and the intention of conference and process. Introducing track chairs to one another has already established a number of new connections that were evidenced in the discussion during the second day. Many follow-ups have taken place (not least for me!) and this will only continue, developing both the social and academic community of design educators.

Fourthly, it will improve the academic quality of the work. By making gate process more visible it becomes more easily open to questioning and scrutiny (something also encouraged directly by Erik and the team). This, in turn, helps co-develop a community understanding of quality as well as the boundaries of this quality. It also supports and fosters new academics, helping them to see what a peer review process is (and is not!), as well as inviting them to contribute to its shaping.

Finally, however it has been achieved, there was no sense of anyone acting as if they knew more than anyone else - no grandstanding; no arrogance; no 'appeals to authority'. This felt like a community willing to listen to and evaluate each others' experience of knowledge and quality in design education research. This is the best traditions of a Community of Practice - something familiar to designers and design educators alike.

And, of course, it's critical not to forget the importance of facilitation and organisation. All too often the work behind the scenes is invisible and the event itself can seem easy, simple and effortless. That the team made it look like easy was obviously due to significant effort and professionalism. The event was superbly hosted (accommodating, personable, relaxed, inclusive) and felt clearly supported academically and professionally.

The Derek's account has captured the spirit the organisers aimed to foster a more inclusive and open collaboration to break away from the dominant hierarchical conference planning and organisation. The idea was to bring on board voices which are generally excluded from these events which meant to preconfigure (Raekstad & Saio Gradin, 2019) and distribute the decision making and responsibility to a wider cohort of participants.

Following the Exploration of Alternate Futures symposium, the contributing authors were notified of their submission status. Thirty percent of the submissions were accepted, and 35% were provisionally accepted, requiring a second round of revisions which were managed by the specific track chairs. The camera-ready papers¹⁰ were finally received on the 8th of June 2021. This meant the organisers were ready to work on the conference proceedings and prepare the conference programme.

Decision Time

Around this time, May 2021, a difficult decision had to be made, of carrying out this conference online rather than face to face in China, under the generous hospitality of SUAD. The main reasons for this were the ongoing Covid-19 pandemic, and the difficulties due to traveling restrictions and different travel administrations across the world. It would have been wonderful to have the conference face to face in China, and meeting with the DRS LxD 2021 community there, but unfortunately this has not been possible.

Regardless of the change of setting, the conference preparations continued for hosting a memorable

¹⁰ These would form these conference proceedings.

conference and accommodating the community in the best ways possible. Many long working hours, working out of details and resolving technical issues have taken place in the background, from a group of dedicated people. Special thanks are owed to Jianglong Yu, the Conference General Secretary, and the Local SUAD Team, in the coordination of all this.

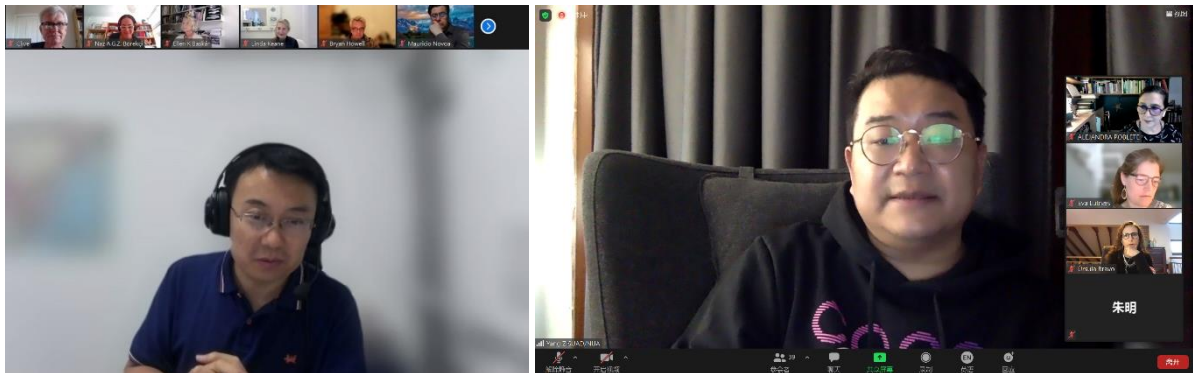


Figure 11. On the left, Jianglong Yu, the Conference General Secretary who worked closely with Yang Zhang, the International Academic Organising Committee co-chair.

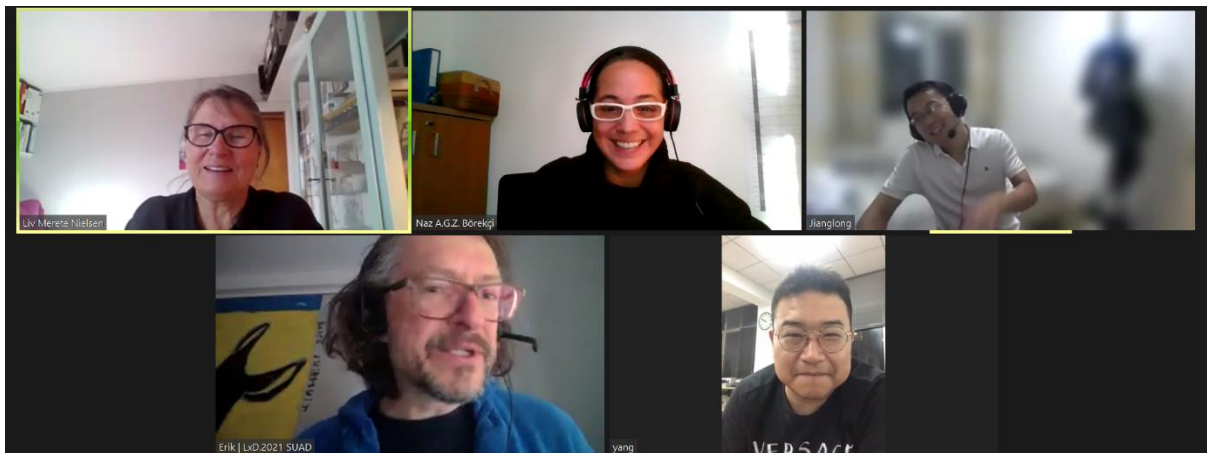


Figure 12. One of the many regular planning meetings of the International Academic Organising Committee members



Figure 13. The local conference organising team was led by SUAD President Professor Pan Lusheng

Conference Visual Identity

A sense of community can be conveyed and strengthened with the branding and visual identity for a conference. Many thanks to Katja Thoring for her efforts in developing the visual identity for the DRS LxD 2021 conference. She has produced countless propositions for the logo and its adaptation into graphic assets to be used on the conference website, proceedings cover, submission templates, social media announcements and email banners.



Figure 14. 'Call for Submissions' website banner (author: Katja Thoring)



Figure 15. 'Call for Submissions' DRS banner (author: Katja Thoring)

With the hopeful expectation of the conference to take place face to face in China, she also has developed propositions for prints of fabric masks to be distributed to participants (Figure 17, left). The DRS LxD 2021 logo is based on the "X" of the conference's name. The initial ideas were developed in SUAD, with the green splash centred in order to form the "X", indicating the "mark" that the conference leaves behind. Katja developed this idea into a fuzzy but focal "X", representing the intersection of dense and repeated movements, indicating the crossing of paths and leaving multi-coloured marks as a community.

The conference visual identity was strengthened with the fascinating graphics developed exclusively for the DRS LxD 2021 conference, by students from Chinese universities, co-ordinated by their professors, and by the Local SUAD Team. More than 100 separate images were produced, representing the ox, which is the zodiac sign of the year 2021 (Figure 17, Right). In Chinese culture, the ox symbolises wealth, prosperity, diligence, and perseverance. This Chinese zodiac sign marks the year 2021 as one of heavy responsibilities and endurance, to which it is surely easy to relate.

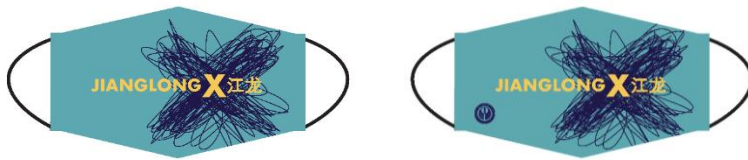


Figure 16. Mask design by Katja Thoring which protected the conference participants as well as identify them, thus reducing the need to produce name badges.

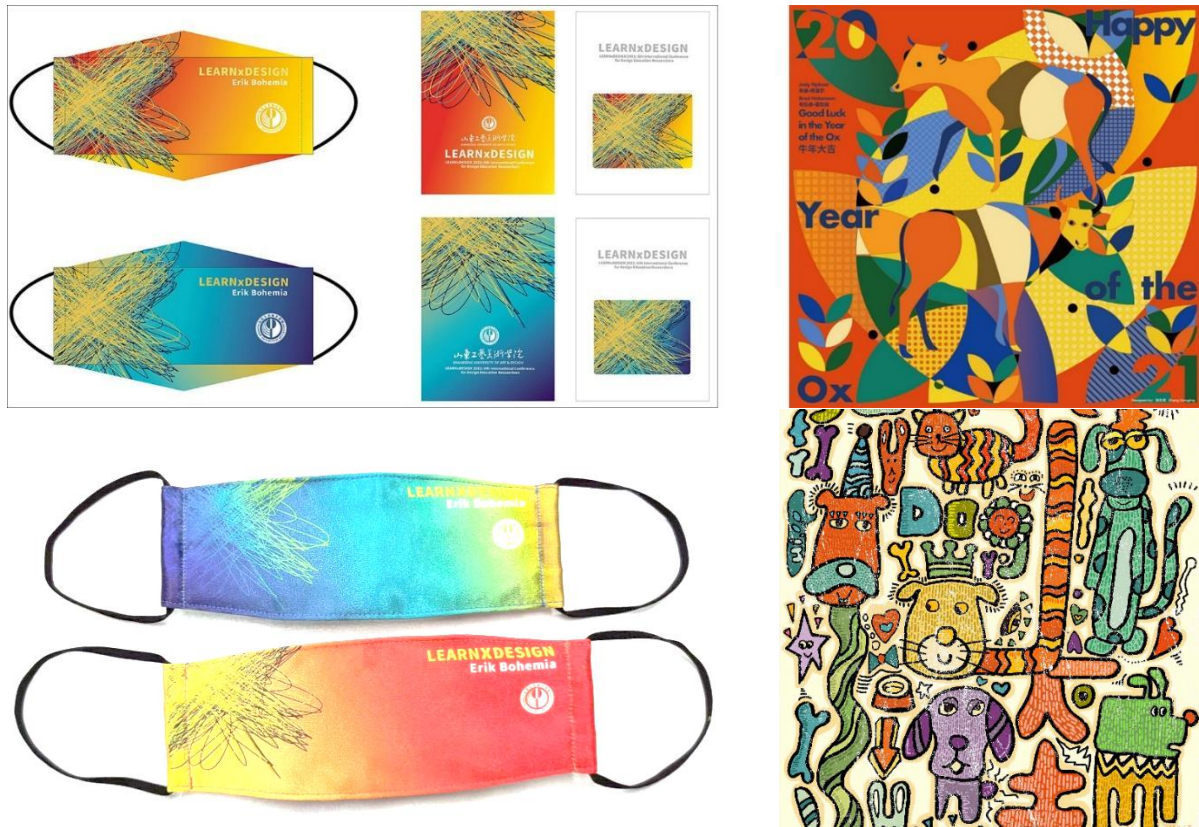


Figure 17. Left: Early visual identity explorations for conference participants' masks and proceedings cover, by Prof. Zhang Yan. Right: An example of the graphic images produced by SUAD for the "year of the ox" of the "year of the dog".

Conference Programme

The DRS Learn X Design 2021, 6th International Conference for Design Education Researchers has accommodated ten tracks responding to the main conference theme *Engaging with Challenges in Design Education*. The proceedings have been organised into 10 sections each corresponding to one of the ten tracks. The tracks' chairs and the co-chairs introduced by the specific (Berg et al., 2021; Börekçi, Korkut, & Hasdoğan, 2021; Bravo et al., 2021; Hartvik et al., 2021; Howell et al., 2021; Kardar et al., 2021; Lutnæs et al., 2021; Noel et al., 2021; Thoring et al., 2021; Xia et al., 2021). We would like to thank the track chairs and co-chairs for their involvement in the chairing of the tracks, and the selfless work they have placed into the quality of the track contributions (Table 2, page 5).

To enable the participation of delegates from all over the world within reasonable day times, the International Academic Organising Committee decided to schedule compact daily programmes lasting around 5 to 6 hours, including frequent social breaks. The compacted schedule resulted in having up to 8 parallel sessions to accommodate the accepted presentations and workshop deliveries. Taking the Central European Time as the basis, the programme hours indicated an early morning for the participants located in the Western Hemisphere, afternoon time for those located around the Greenwich Time Zone, and the evening times for the participants located in the Eastern Hemisphere.

Scientific Programme

In total, the scientific programme of the conference included 28 presentation sessions for the delivery of 80 research papers, case studies and visual papers, and 12 workshop sessions for the delivery of 11 workshops. The three-day programme for the conference accommodated plenary sessions to begin each day.

Day One

On the first day, 24 September 2021 Friday, following the conference opening by Erik Bohemia, the welcome speeches were given by Professor Pan Lusheng, the President of SUAD (see Figure 20), the general conference chair; and Professor Liv Merete Nielsen (see Figure 30), the chair of the International Scientific Programme Committee. The plenary session of the first day included keynote addresses by the five track chairs: Linda Keane, Úrsula Bravo (see Figure 19), Eva Lutnæs (see Figure 18), Naz A.G.Z. Börekçi and Bryan Howell. Two parallel sessions were carried out, one for paper presentations and one for the workshops.

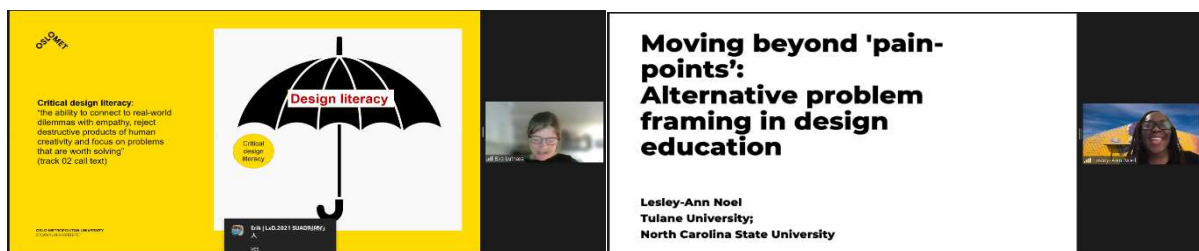


Figure 18. On the left Eva Lutnæs introducing the track Empowering Critical Design Literacy and on the right Lesley-Ann who chaired the track Moving Beyond Pain-Points: Alternative Problem Framing in Design Education.



Figure 19. Úrsula Bravo introduces the track Design Thinking to Improve Creative Problem-solving.

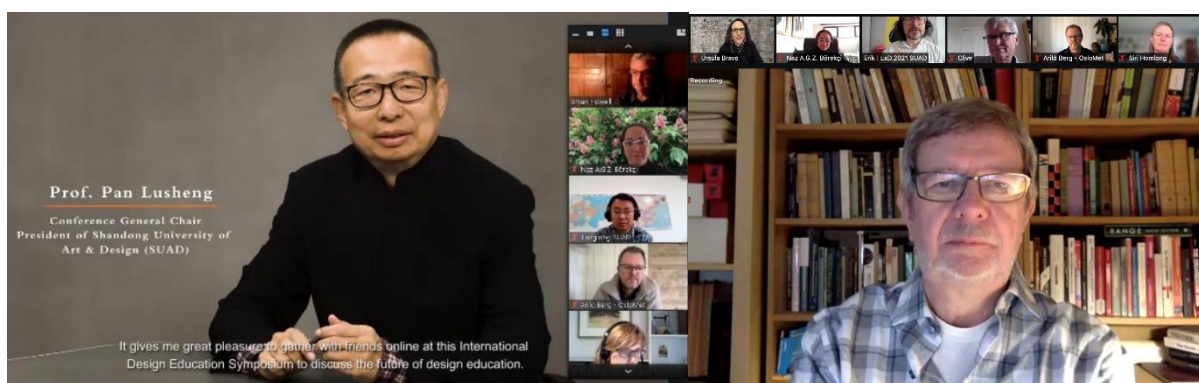


Figure 20. Left: Professor Pan Lusheng, President of SUAD, giving his welcome speech, 24 September 2021. Right: Professor Richard Buchanan, giving his keynote address, 25 September 2021.

Day Two

On the second day, 25 September 2021 Saturday, the plenary session included keynote addresses by the three track chairs: Lesley-Ann Noel (see Figure 18), Arild Berg, and Xiang Xia.

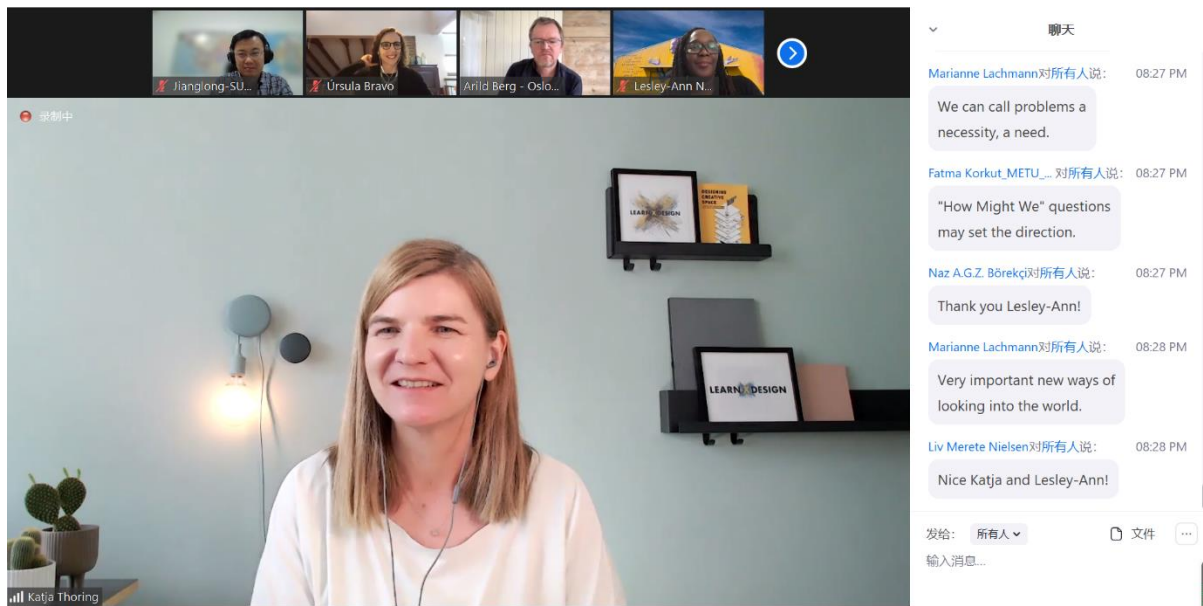


Figure 21. Katja Thoring, who chaired the track Design Learning Environments, is addressing questions from participants.

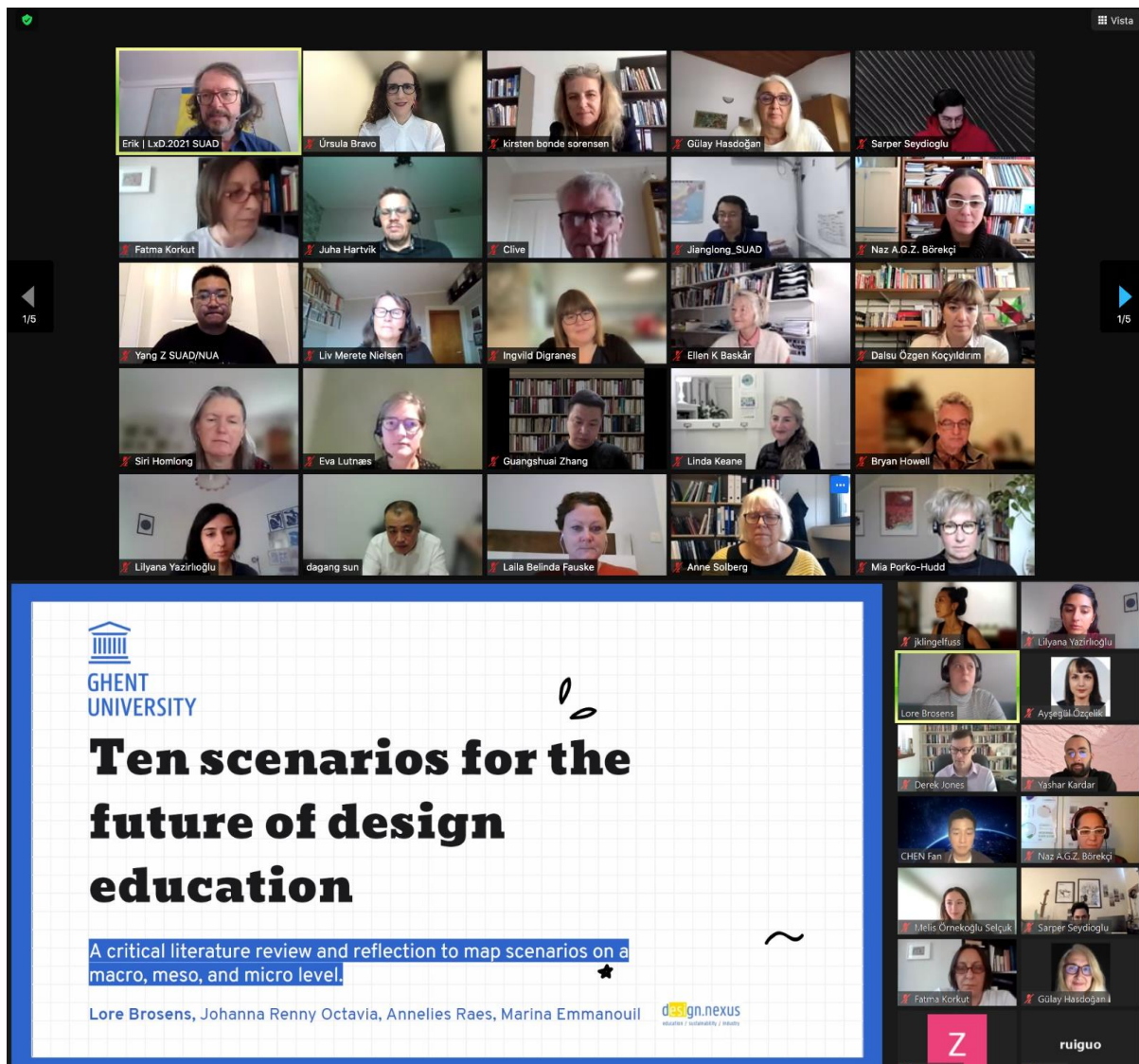


Figure 22. Presentation by Lore Brosens

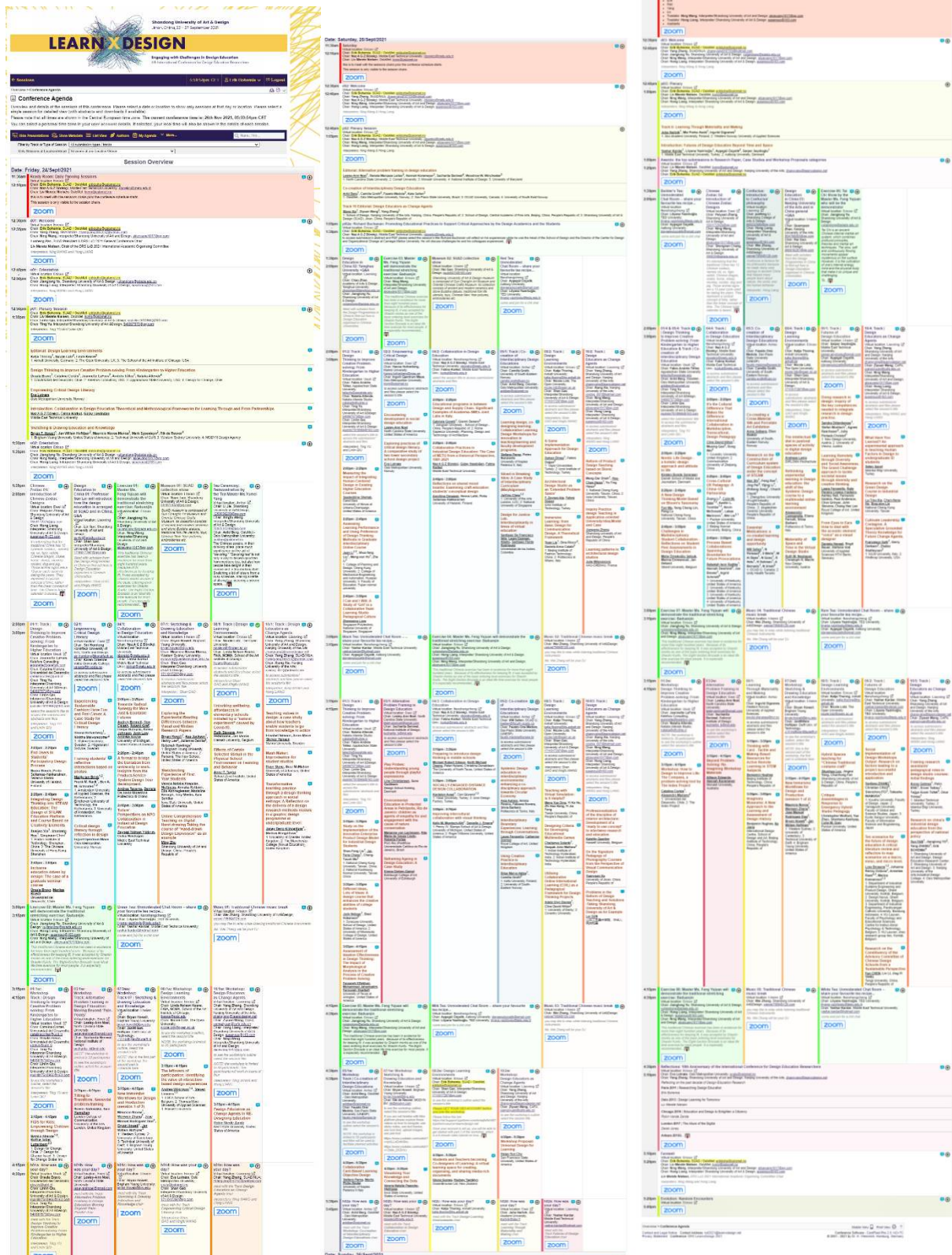


Figure 23. The three-day conference programme pattern of session distribution. Each column represents one of days, from left day 1, middle day 2 and on the right is the day 3.

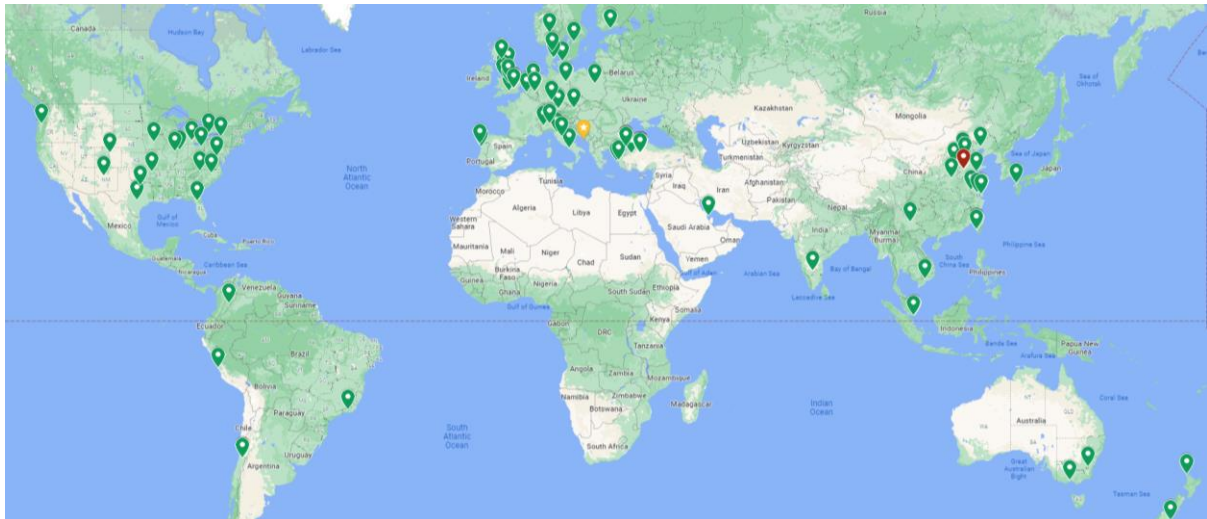


Figure 24. The distribution of authors of the accepted submissions.

This was followed by the keynote address by Professor Richard Buchanan, titled *Promoting Educational Practices to Support Critical Approaches by the Design Academics and the Students*. Richard Buchanan is Professor of Design & Innovation at Weatherhead School of Management, Case Western Reserve University and Chair Professor of Design Theory, Practice, and Entrepreneurship, College of Design & Innovation, Tongji University. He is one of the editors of the *Design Issues: A Journal of design history, theory, criticism* published by MIT Press. Buchanan reflected on his experiences while he was the Head of the School of Design and the Director of the Center for Design and Organizational Change at Carnegie Mellon University (Buchanan, 2004). He discussed the challenges he and his colleagues experienced while trying to develop educational practices which will support critical approaches by the design academics and the students. Although most of the design schools, faculties, departments are aiming to develop more critical practices, implementing and embedding the critical pedagogical practices are extremely challenging as it requires the cultural transformation of the practices of how the design academics are trained (educated), see Figure 20.

Three parallel sessions were conducted on this day, dedicated mostly to paper presentations and for workshops.

Day Three

On the third day, 26 September 2021 Sunday, the plenary session included keynote addresses by the two track chairs: Juha Hartvik and Yashar Kardar.

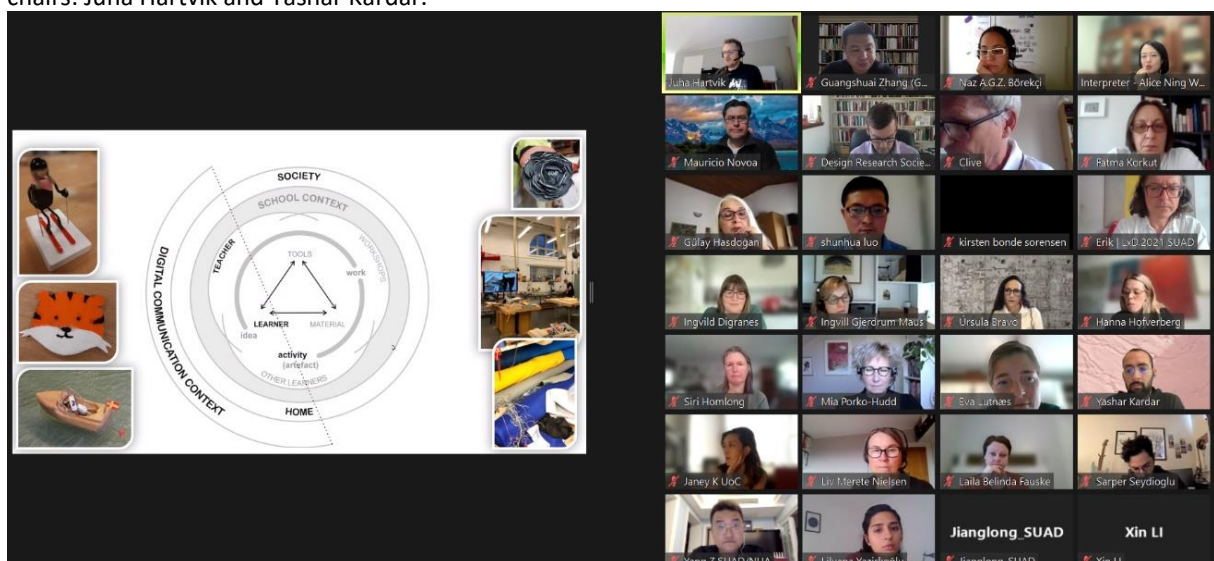


Figure 25. Juha Hartvik introducing the track Learning Through Materiality and Making.

This was followed by the announcement of the awards, *Top Submissions in Research Paper, Case Studies and*

Workshop Proposals Categories, carried out by Liv Merete Nielsen and Yang Zhang. Two parallel sessions were conducted on this day for paper presentations and workshops.

Top Awards

Three categories for top awards were selected based on the double-blind evaluation from the peer review members of the *International Scientific Review Panel*. The three categories were: Research Paper, Case Studies and Workshop Proposals. They are listed alphabetically following the first author's name.

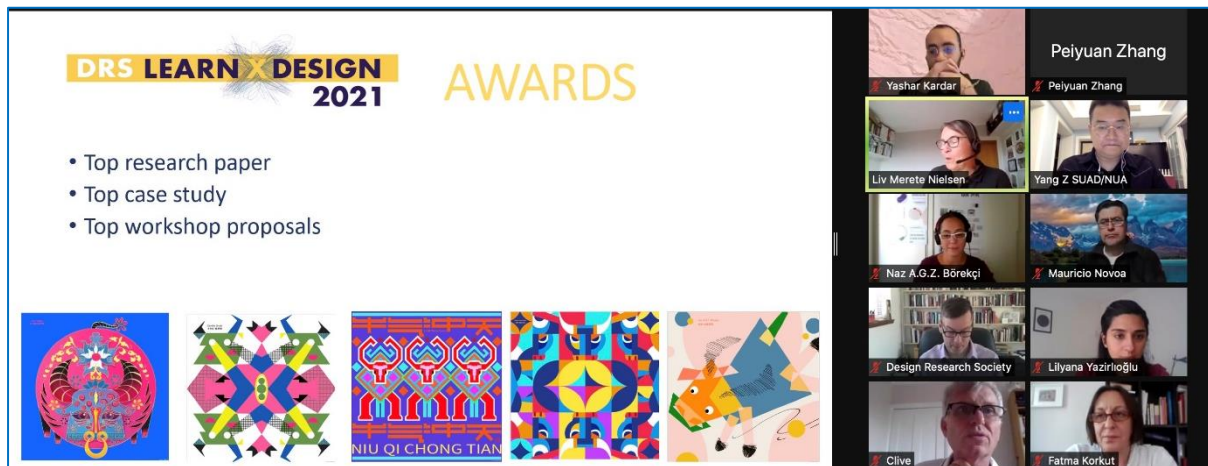


Figure 26. Liv Merete Nielsen and Yang Zhang chaired the Awards Ceremony for the research and visual papers, workshop proposals and case studies.

Top Research Papers

The following nine research papers were awarded.

- Systemic Design Education in Interdisciplinary Environments: Enhancing A Co-Disciplinary Approach Towards Circular Economy
Track 05, A. Aulisio; A. Pereno; F. Rovera; S. Barbero
- Ten Scenarios for the Future of Design Education: A Critical Literature Review and Reflection to Map Scenarios on a Macro, Meso, and Micro Level
Track 10, L. Brosens; J. R. Octavia; A. Raes; M. Emmanouil
- Collaboration Practices in Industrial Design Education: The Case of METU from a Historical Perspective, 1981-2021
Track 04, N. A. G. Z. Borekci; G. Hasdoğan; F. Korkut
- Exploring the Experiential Reading Differences Between Visual and Written Research Papers
Track 07, B. Howell; A. Jackson; H. Lee; J. DeVita; R. Rawlings
- I Can and I Will: A Study of 'Grit' in a Collaborative Team Learning Studio Pedagogical Culture
Track 01, Z. Liow
- Study on the Implementation of the Innovative Enterprise Product Design Model for Industrial Design Students
Track 01, S.-F. Liu; J.-F. Chang; C.-T. Wu
- Different Ideas, Lots of Ideas: A Design Course that Enhances the Creative Abilities of College Students
Track 01, J. Nyboer; B. Hokanson
- Measuring the Impact of Integrating Human-Centered Design in Existing Higher Education Courses
Track 01, S. Shehab; C. Guo
- Reform of Product Design Teaching Based on Bionic Concepts
Track 11, M.-D. Shieh; H.-C. Hsiao; Y.-T. Hsiao

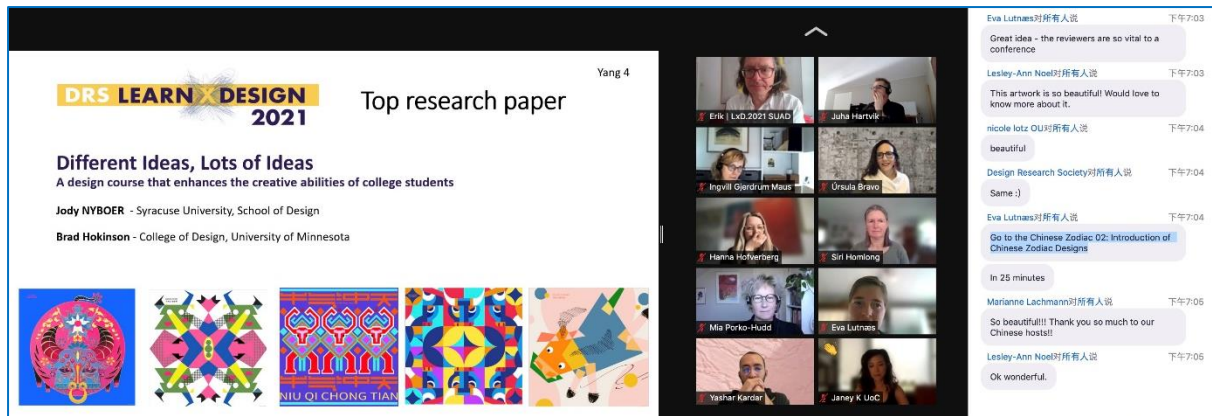


Figure 27. Presentation of Awards in the Research Papers category

Top Case Studies

- Preparing to Introduce Design Thinking in Middle Schools
Track 04, M. R. Gibson; K. M. Owens; P. Hyland; C. Donaldson
- Essential Siloed in Breaking Silos: A case of Interdisciplinary Curriculum (Mis)Alignment
Track 05, JiaYing Chew
- Mash Maker: Improvisation for Student Studios
Track 11, R. Slone; B. McMahon

Top Workshop Proposals

- Workshop: How to Design to Improve Life: The Compass, A Problem-Solving Tool by The Index Project
Track 01, C. Cortes; M. Alesandro
- Tilting to Transform: Sensorial Problem-Framing
Track 03, N. Sadowska; T. Hanrahan

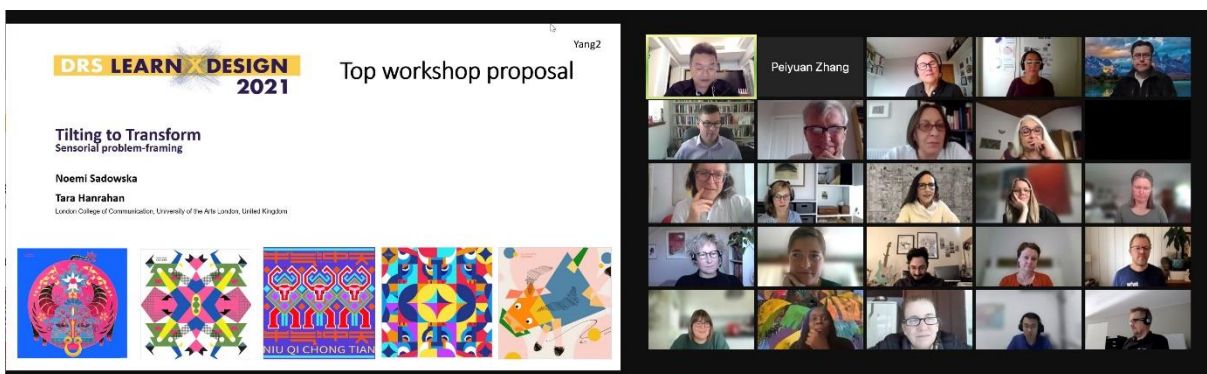


Figure 28. Presentation of Workshop Proposals Awards.

The final plenary session celebrated the 10th anniversary of the Learn X Design conference series. This session brought together the organisers and chairs of the past Learn X Design conferences: Erik Bohemia, Paris 2011 (Bohemia, 2021); Liv Merete Nielsen, Oslo 2013 (Nielsen, 2021); Robin Vande Zande, Chicago 2015 (Vande Zande, 2021), Derek Jones, London 2017 (Jones, 2021) and Fatma Korkut, Ankara 2019 (Börekçi, Korkut, & Koçyıldırım, 2021) were invited to present their reflections on “the ways in which the conferences have contributed to the development of design education research.” Their reflections also are included in this conference proceedings.

During this session, the early career researchers who have organised the Futures of Design Education track shared their insights with the conference delegates. Lilyana Yazirlioğlu, one of the members, said that:

...with the conference, I had a chance to discover what is going on in the backstage of preparing an international conference from selection of themes to reviewing papers and preparing the online

conference setting which I found quite informative for a recent graduate student and an early career researcher like me. Especially, having discussions with other track chairs to enhance the themes in the early stages of the conference creation process was inspiring since it offered our team a sense of belonging to a bigger and supportive design community.

Lilyana's team member Yashar Kardar said that for him:

...this was a great experience! Being part of the conference enabled me to meet and learn from researchers from almost all over the world, and work closely and learn from experienced, passionate, and encouraging people such as Erik Bohemia, Derek Jones, and Naz Borekçi. This created an exceptional chance get an insight into the general state of design education research and the global dynamics influencing its development. It also personally has given me the courage to want to contribute to the design research community at a much larger scale. I think activities that would include young researchers such as myself, and members of my team build an incredible opportunity to empower young researchers from all over the world. We think that the mixing of scholarly discussions at a high level and social interaction is at the core for making these conferences attractive and important.

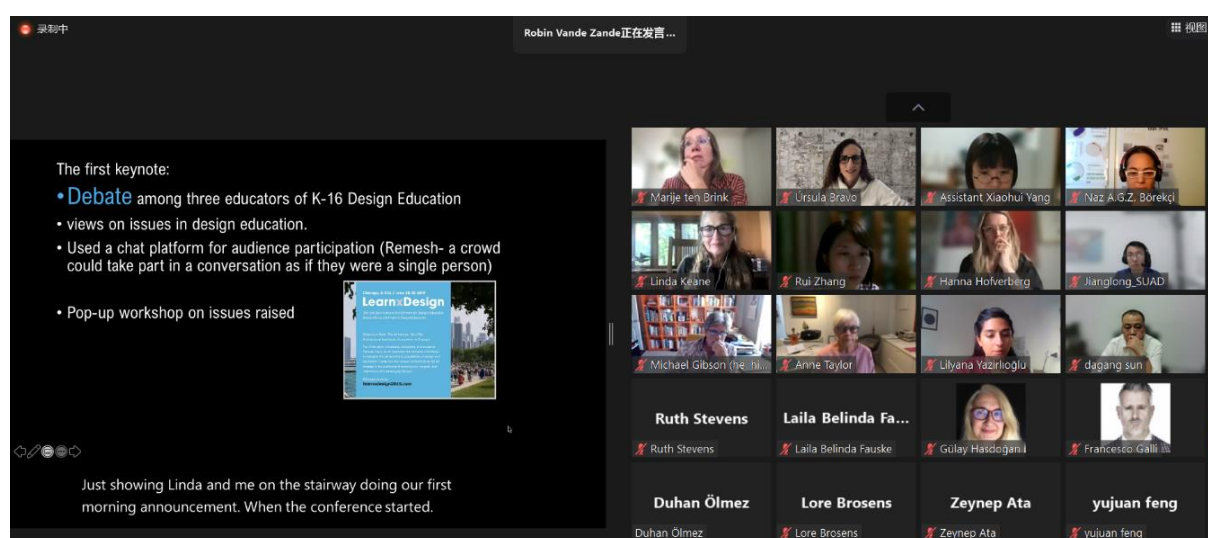


Figure 29. Robin Vande Zande reflected on the 2015 LxD conference which was hosted in Chicago.

The farewell speech for the conference was given by Professor Xin Li (see Figure 30), Vice President of SUAD, after which, the conference was closed by Professor Liv Merete Nielsen (see Figure 31).



Figure 30. Professor Xin Li, Vice President of SUAD who closed the conference with her farewell speech



Figure 31. On the left, Lilyana Yazirlioğlu reflecting her and her team members' experience of organising a conference track, and on the right, Liv Merete Nielsen is summarising the event.

Social Programme: Conveying the Significance of Chinese Culture

It was believed that the conference programme would be enriched with social events, both for the conveying of the significance and richness of Chinese culture, and for providing an attractive and embracing medium for the delegates to come together. Various social gatherings were planned for the 15-minute and 30-minute breaks between the sessions, throughout the three conference days. These gatherings included relaxing exercise sessions, where Master Ms. Feng Yujuan demonstrated traditional stretching exercise, the Baduanjin; the audition of traditional Chinese music, and unmoderated chat rooms designated for tea breaks.

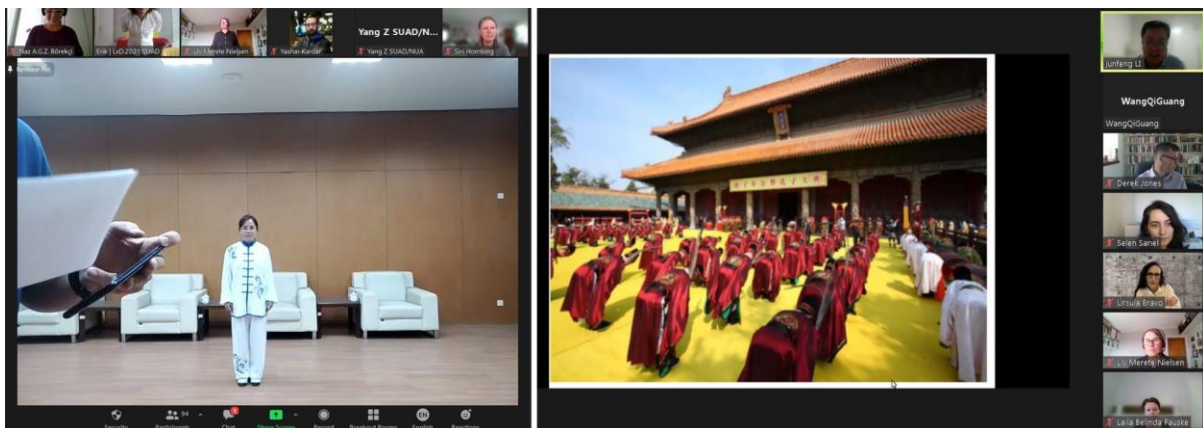


Figure 32. Left: Master Ms. Feng Yujuan beginning her exercise session, 26 September 2021. Right: Professor Junfeng Li presenting on Confucius, 26 September 2021.

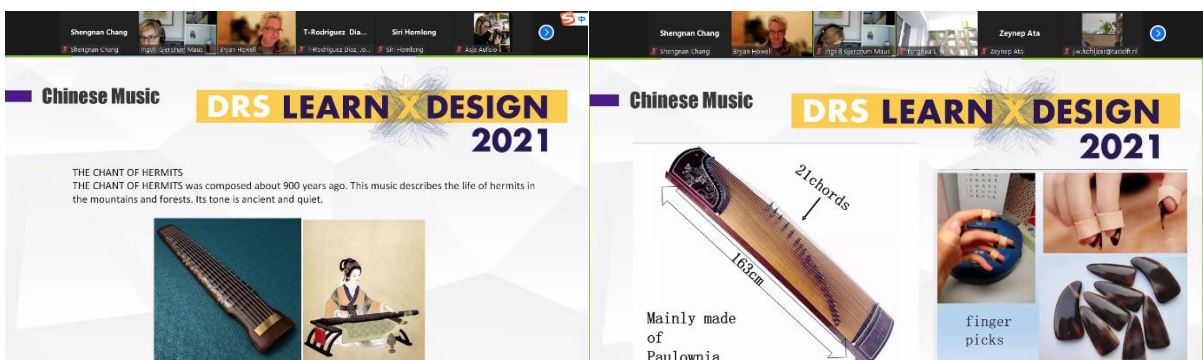


Figure 33. The conference delegates were able to relax during the breaks listening to examples of Chinese music.

A tea ceremony demonstration took place by Tea Master Ms. Yumei Yang. The Chinese people, in their drinking of tea, place much significance on the act of “savouring”. “Savouring tea” is not only a way to discern good tea from mediocre tea, but also how people take delight in their reverie and in tea-drinking itself. Snatching a bit of leisure from a busy schedule, making a kettle of strong tea, securing a serene space, and serving and drinking tea by yourself can help banish fatigue and frustration, improve your thinking ability, and inspire you with enthusiasm. You may also imbibe it slowly in small sips to appreciate the subtle allure of tea-drinking, until your spirits soar up and up into a sublime aesthetic realm. Buildings, gardens, ornaments and tea sets are the elements that form the ambience for savouring tea. A tranquil, refreshing, comfortable and neat locale is certainly desirable for drinking tea. Chinese gardens are well known in the world and beautiful Chinese landscapes are too numerous to count.



Figure 34. Tea Ceremony by Tea Master Ms. Yumei Yang.

The Chinese zodiac signs, and the designs that were prepared by Chinese students for the conference were presented in two break sessions. As in the Western cultures, traditional China has 12 Chinese zodiacs. However, these traditional Chinese zodiac signs are arranged in a 12-year cycle used for dating the years. They represent a cyclical concept of time, rather than the linear concept of time. The Chinese lunar calendar is based on the cycles of the moon and is constructed in a different fashion than the solar calendar. Every year is assigned an animal sign according to a repeating cycle from Rat to Pig. These traditional Chinese zodiacs are: the rat, ox, tiger, rabbit, Chinese dragon, snake, horse, sheep, monkey, rooster, dog and pig (see Figure 34).

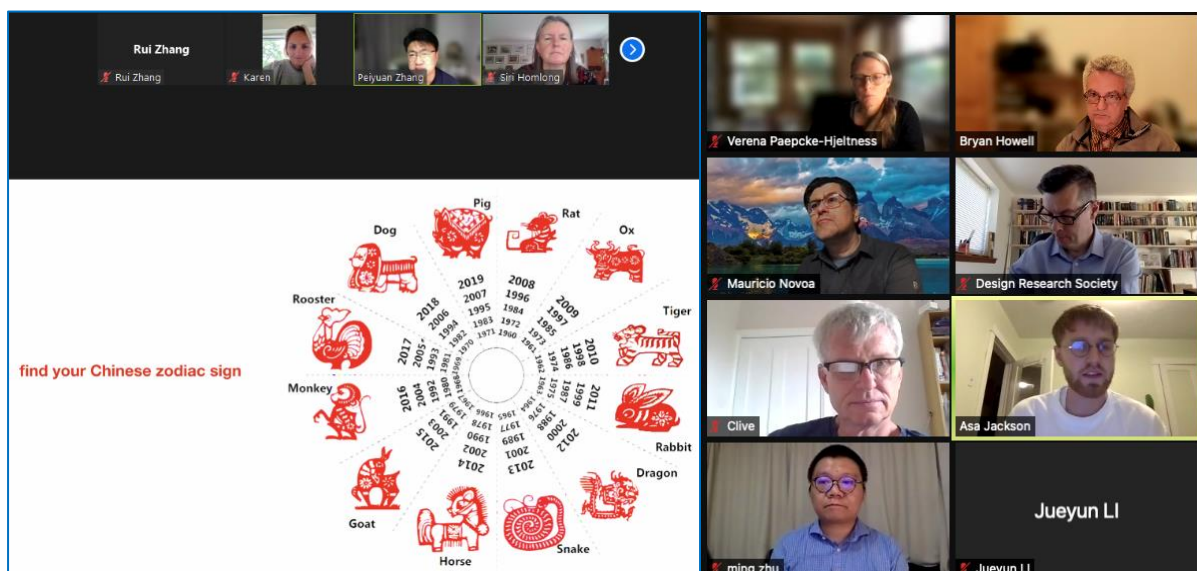


Figure 35. Chinese Zodiac session.

Design education in China was introduced in three break sessions, by Professors: Sun Lei from SUAD; Zhao Chao from Academy of Arts & Design, Tsinghua University; and Zhao Quanquan from Nanjing University of the Arts; describing to the audience how design education is organised at these three top ranking Chinese universities. This was also an opportunity for the conference delegates to meet with scholars from the design

programmes in China.

The SUAD museum, composed of Sun Changlin Art Museum and Oriental Chinese Crafts Museum was presented to the audience in two break sessions. The museum's collection consists of ancient and modern ceramics and stone Buddha statues, traditional folk life utensils, toys, Chinese New Year pictures, embroideries and many more artefacts.

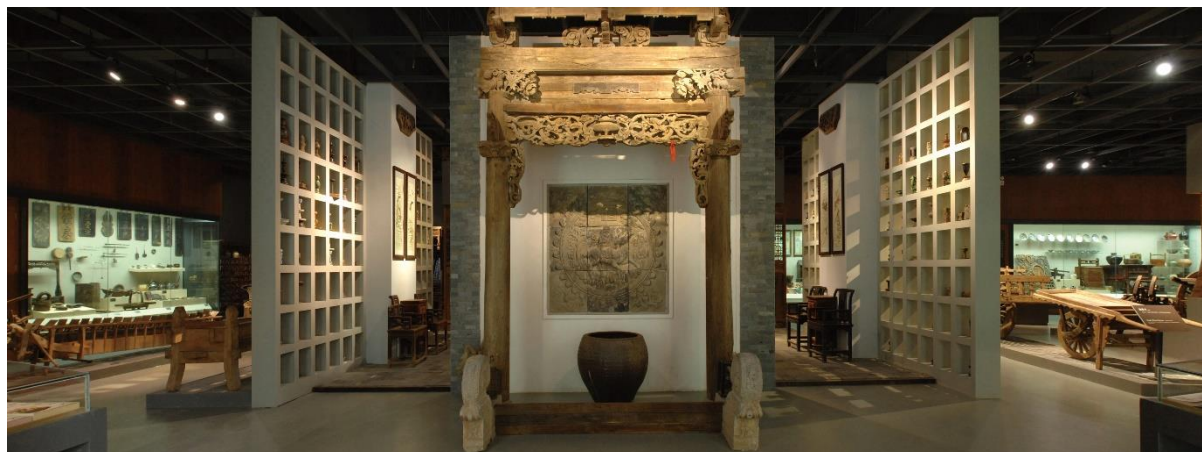


Figure 36. Entrance to the Museum of Folk Arts.



Figure 37. The Museum of Folk Arts.



Figure 38. Introduction to Confucius' Philosophy presented by Professor Junfeng Li.

On the final day of the conference, a presentation was given in the main break session by Professor Junfeng Li titled *Introduction to Confucius' Philosophy*. Confucius is famous for his philosophy because he made many wise sayings in ancient China that helped many people learn about nature, the world, and human behaviour.

All presentations were simultaneously interpreted for the international audience.

The Proceedings

The Learn X Design 2021 conference proceedings have been assembled into 4 volumes. Altogether, there are over 1000 pages of material.

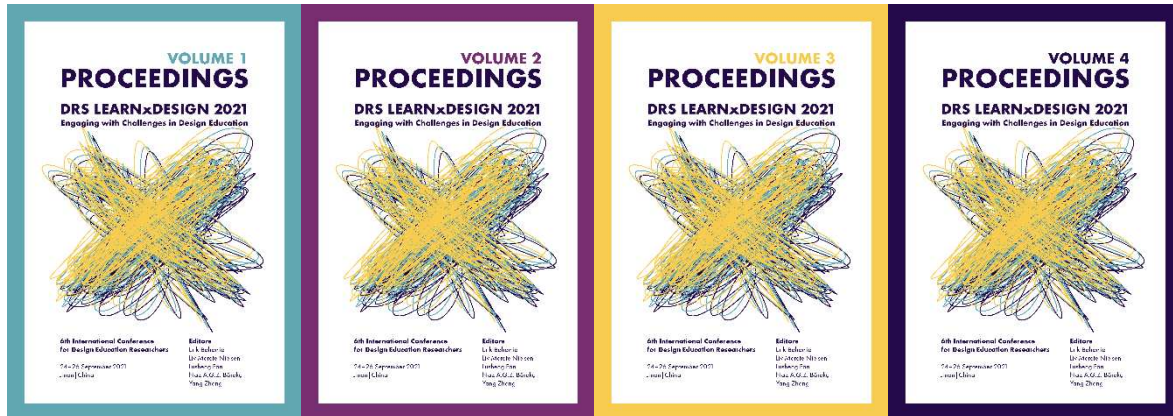


Figure 39. Each of the four volumes' cover pages was allocated one of the conference colours.

The proceedings from each conference reflect how topics have been given priority. Some years the conferences have been further developed and published in special issues of scientific journals. Also, after this conference such special issues will be conducted.

DRS Learn X Design 2021 Community

The conference registration never went on sale as it was fully subscribed, if only the authors and their co-authors of accepted submissions would attend the event. The participation was strictly by invitation only. The invited participants were the authors and their co-authors, the international and the local organising committee members, the track chairs, and co-chairs, 10 bursary holders, and selected scholars based in China.

LEARN X DESIGN Deadline: 20th April 2021

learnxdesign.net/lxd2021

CALL FOR BURSARY AWARDS FOR EARLY CAREER RESEARCHERS FROM THE GLOBAL SOUTH

Engaging with Challenges in Design Education
6th International Conference for Design Education Researchers

Figure 40. Call for Bursary submissions (source: Katja Thoring)

Participants from 28 countries have registered. Over 500 people have actively contributed to a variety of roles such as expert peer reviewers (see the list on page ii), authors (see the Index of Authors on page 1077 in the Volume 4), track chairs and co-chairs (see the list on page i), the local planning and organising committees and assistants (see the list on page iv).

Acknowledgment and Special Thanks

As we conclude this editorial, we would like to thank the Shandong University of Art & Design for generously hosting the DRS Learn X Design 2021: 6th International Conference for Design Education Researchers. We would like to thank you to the SUAD Council's for taking the steps to enable diverse scholars from all around of the world to contribute advancing the field Design Education Research by lowering the barriers and to enable participation of scholars from marginalised communities by kindly offering to cover the registration cost for the Track Chairs/co-chairs and Authors/co-authors of accepted submissions, keynotes and those awarded SUAD President's bursaries to attend the conference.

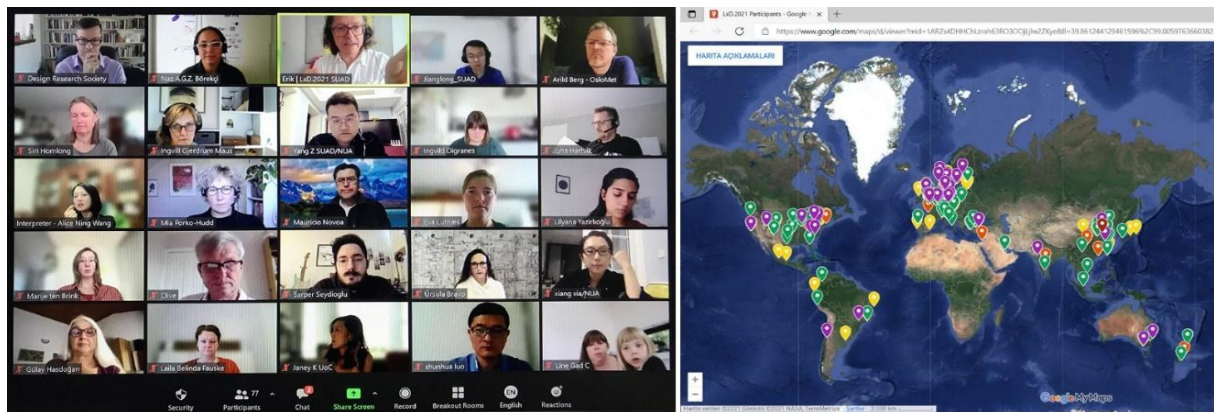


Figure 41. Left: A moment in the conference on Zoom, 26 September 2021. Right: Distribution of the LXD 2021 community across the world, Google My Maps.
<https://www.google.com/maps/d/u/0/edit?mid=1ARZs4DHHChLzrah63RO3OOjLjw2ZKye&usp=sharing>

We also thank the Design Research Society Special Interest Group in Design Education, DRS EdSIG, for giving us the opportunity and trust to organise it. We would like to thank the General Conference International Planning Committee, International Academic Organising Committee, Patrons of the Conference, International Scientific Programme Committee, and International Scientific Panel for their contribution. We would also like to thank the following institutions that have provided their kind support in the realization of the conference: Design Literacy International Network, Hochschule Anhalt, Hochschule für Wirtschaft und Recht Berlin, Middle East Technical University, Oslo Metropolitan University, The Open University (UK), Tulane University, Universidad del Desarrollo and Åbo Akademi University.

We felt the power of the community with this conference, however online, and found it to be a good opportunity for the community to expand itself in numbers, as well as in knowledge and mindsets. We hope that it has been a fulfilling conference experience for its participants also. We thank the DRS Learn X Design 2021 community for contributing to the conference and taking an active part in its realisation. It is not yet decided who will host the 7th DRS Learn X Design conference in 2023. In line with the previous conferences, we will be very happy to support those who will contribute to the continuity of design education research. Endings for events are never easy, especially when there is a lot of time and commitment involved. Nevertheless, we consider endings to be new beginnings. We will now begin a new decade for the DRS Learn X Design conference series and look forward to meeting with the design education researchers community in 2023.

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Ankara 2019 – Insider Knowledge

Reflections on the Fifth International Conference for Design Education Researchers

Naz A.G.Z. Börekçi, Fatma Korkut and Dalsu Özgen Koçyıldırım
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The fifth conference of the Learn X Design series, DRSLXD2019, was held in Ankara between 9-12 July 2019, hosted by Middle East Technical University (METU). It all started in London, at the Learn X Design 2017 conference, with the encouragement of the DRS Special Interest Group in Design Pedagogy (PedSIG) convenor of the time for our application to bid for hosting the next conference of the series, and continued with the support of Derek Jones, the next DRS PedSIG convenor, and Peter Lloyd, Chair of the DRS Council at the time. We were thrilled to learn that we were given the opportunity to be the next hosting institution. The year 2019 had a special meaning for us; it marked the 50th anniversary of the first course on industrial design offered in Turkey at METU Faculty of Architecture by the American industrial designer David K. Munro. 2019 also was the 40th anniversary of the establishment of the Department of Industrial Design as a separate undergraduate programme at METU.

While planning for the conference, we aimed for a fulfilling conference experience for all involved, from the conference academic scope to the social events, with a strong visual identity that would support in making the conference unforgettable for the delegates. We found our inspirations among the local values of the region. The name Ankara, as in the capital city of Turkey, comes from the word anchor, representing the strategic location of this ancient city that has hosted many civilizations and acted as the intersection of routes between Asia, Africa and Europe. The METU campus, with its built environment including the iconic Faculty of Architecture building, as well as the natural environment it embraces resulting from generations-long forestation effort, was also a rich resource. Finally, we based our visual identity on the Anatolian carpet motifs, and highlighted the eight-point star as the “X” of the conference series name, and the interwoven colours to represent “the crossing of paths” and “coming together” (Figure 1).



Figure 1. The conference title and graphics.

We determined our main theme as “Insider Knowledge”, referring to the knowledge, know-how, skill sets and mindsets developed, implemented and internalised throughout time by the design education research community at large. We were in consensus that this was what we wanted to achieve with this conference: providing a milieu where we could open up our *insider knowledge* to the use of others, in order to share, generate, interact and learn.

As we wanted to make sure the conference call was widely disseminated, we started our preparations early, in October 2017. We initially worked out the main conference theme, developed the visual identity, and finally prepared our website, to make our call for tracks in May 2018. We had a wide range of responses, and as a result, we were able to make the call for papers in July 2018. The deadline for paper submission was 30 December 2018. Forty-two track chairs were involved in this process of building the conference scope. For the new year of 2019, we had 111 paper submissions and 11 workshop proposals submitted to 17 conference



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tracks. We also had 28 PhD Pit-Stop applications to review. There were 119 reviewers involved in the two rounds of double-blind review, ensuring a high quality in the submission selections and revisions. As a result, 87 papers and five workshops were accepted for the conference.

The conference programme was set up to accommodate a full-day PhD Pit-Stop on the first day, with three workshops running in parallel. Twenty-four PhD researchers joined the PhD Pit-Stop. The PhD Pit-Stop was supported with four short plenary lectures by Gülay Hasdoğan, Owain Pedgley, Peter Lloyd, and Gülşen Töre Yargin, open to the participation of all delegates, besides the PhD researchers. PhD researchers made their presentations and received feedback provided by the mentors in the morning, and they joined a workshop in the afternoon (Figure 2, left), where they were able to discuss their research interactively with all mentors involved. On that evening, the conference welcome reception was held at the front garden of the Faculty of Architecture (Figure 2, right). We believe this first day, and the social event concluding it at a karaoke bar, were among the events characterising the conference.



Figure 2. Left: PhD Pit-Stop workshop in the afternoon. Right: Conference welcome reception at the Faculty of Architecture front garden in the evening, 9 July 2019.

The following three days of the conference accommodated two more workshop sessions running parallel to 27 paper presentation sessions. We had either two or three parallel sessions for paper presentations (Figure 3, left). In total, we had 150 delegates from 88 institutions spread across 27 countries.



Figure 3. Left: Paper presentation session. Right: Concluding panel on the final day, 12 July 2019.

Each day, the first session in the afternoon was a plenary keynote address (Figure 4). The conference brought together an enormously powerful group of keynotes, three women academics, located in different parts of the world. The keynote of the first day was Gabriela Goldschmidt, with her keynote address titled “Disciplinary Knowledge and the Design Space”. The keynote of the second day was Zeynep Çelik Alexander, with her keynote address titled “Drawing Circles”. The keynote of the concluding third day was Halime Demirkan, with her keynote address titled “Learning and Knowledge Building Skills in Design Education”.



Figure 4. Keynotes from left to right: Gabriela Goldschmidt, Zeynep Çelik Alexander, Halime Demirkan.

The final day of the conference concluded with a panel titled “Design Pedagogy for Future Generations”, moderated by Derek Jones, and with the participation of İpek Akpınar, Aykut Coşkun, Emre Çağlar, Stanley Ruecker and Yasuko Takayama. This panel addressed the changes expected in design pedagogy in the forming of the new generations of designers, and how design education research can contribute to the skill sets and mindsets that they are expected to acquire for their professional careers (Figure 3, right).

We believed it was important to be able to support the conference community in an inviting environment. We wanted the conference venue to reflect the conference visual identity, and accommodate the technical and social needs of the delegates. The venue was furnished by one of our sponsors to host the social gatherings during coffee and lunch breaks (Figure 5, left), as well as to provide quiet areas for the delegates. There were also two sponsored exhibitions in the venue: a photography exhibition on the work of contemporary Turkish architects, and an exhibition of glassware products by Turkish and international designers. We did our best to prepare a joyful conference pack that included the book of abstracts and pins for social events (Figure 5, centre and right).



Figure 5. Left: Conference venue during lunch break. Centre: Conference pack. Right: Book of abstracts.

Our social programme aimed to reflect various aspects of celebrating, including a glimpse into the rituals of bathing in the traditional Turkish bath (Figure 6, left), and dining in a traditional restaurant. The conference dinner was a true celebration of coming together, hearing each other out and understanding different points of view, and the hearty participation of 300 people singing and (belly) dancing together was a wonderful experience (Figure 6, right). We said our final goodbye to the delegates on the last day in a local neighbourhood pub, following the closure of the conference.



Figure 6. Left: The Turkish bath visit, 10 July 2019. Right: The conference dinner, 11 July 2019.

We believe we have learnt a lot from this 21-month experience. Before the conference, during the preparations, we learned the value of developing and agreeing on a shared goal, and how this can bring parties, located in different parts of the world, closer. Our belief in hard work, team effort, collaboration, compromise and friendly communication has been strengthened. Having to work early morning hours and late evening hours, and running against deadlines reminded us of effective time planning, efficient coordination and prompt responses to enquiry. During the conference, we remembered the value of cultural, institutional and personal diversity, and of having young and senior researchers together. We were inspired by new knowledge, and its power in building a global design education research community. We also discovered the strength of social media, supported by branding and visual identity, which we made use of before, during and after the conference, in effectively communicating to reach out and keep in touch.

The website for the DRS Learn X Design 2019 Fifth International Conference for Design Education Researchers may be accessed from: http://drslxd19.https://doi.org/10.21606/drs_lxd2021.metu.edu.tr/ From this webpage it is also possible to download the conference proceedings book.

With this experience, we once again were able to see that it is people that bring an event to life, give it meaning, and pass its legacy onto future generations. We thank the organisers of the DRSLXD2019 conference, DRS PedSIG and METU. We also thank the Programme Committee, International Board of Reviewers, track chairs, keynotes, short lecturers, PhD Pit-Stop mentors, workshop organisers and panellists. We thank our sponsors, Ankara Embassy of Israel, BSH, Nude, Nurus, MPV Mustafa Parlar Foundation, and METU. We also thank the local administrative team, editorial support team, visual communication support team, and the conference team who were out on the field, showing an amazing effort in the realisation of the event (Figure 7).



Figure 7. The conference team, during preparations.

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London 2017 – The Allure of the Digital and Beyond

Fourth International Conference for Design Education Researchers

Derek Jones

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The fourth international DRS PedSIG Conference on Design Education, LearnXDesign 2017, was held at the end of June 2017 in London, UK. Titled “The Allure of the Digital and Beyond”, the conference aimed to:

“...bring together researchers and practitioners with an international reach and from a wide variety of education design settings with the intention of connecting emergent models and ideas around the digital, with the scholarship of teaching and learning”



Ravensbourne University Greenwich Campus (right) in front of the O2 Arena, London.

The conference was hosted by Ravensbourne University in their stunning Greenwich peninsula campus, in the heart of London and directly adjacent to the O2 Arena. On the second night, the River Thames served as a backdrop for ‘free’ fireworks, creating an unforgettable setting for delegates to reconnect or make new connections. The Learn X Design conferences are particularly collegiate experiences and the community gathered in London reinforced this meeting of passionate design educators and practitioners.

The conference hosted nine paper sessions presenting 42 papers, making the conference a very focused event with very involved and detailed discussions. In fact, it was perhaps the scale of event that led to such successful interactions and discussion during the paper presentations: time was available for extended debate and interaction and it rarely felt that we were rushing to the next session.

The opening keynote by Susan Orr (@Susan_K_Orr) superbly summarised the current landscape in design education, focusing on significant aspects of core design pedagogy and noting how these are being understood in our own discipline(s) as well as how they could transfer to other subject domains. Looking into the near future, she described design as continually developing, where “students are the definers of the discipline”.

On the second day, keynote Jo Twist (@Doctoe) demonstrated just how significant the games industry in the UK is - both economically and as a discipline and professional endeavour. She observed that “play allows you to fail” before calling for even greater integration between the Arts and traditional (but unhelpfully segregated) STEM subjects that often lead game design.



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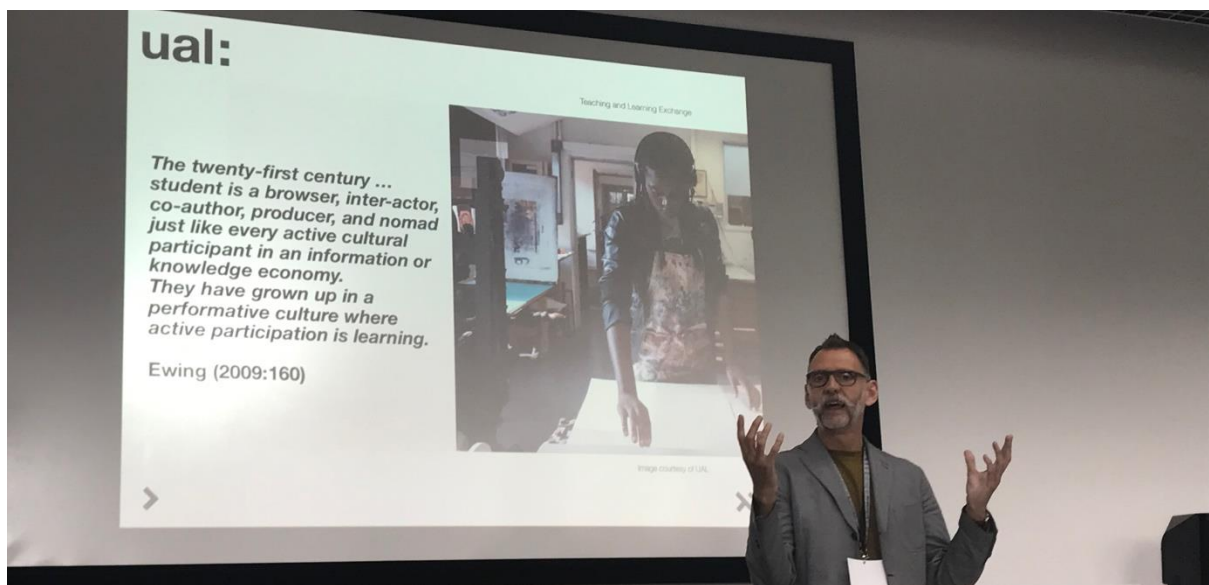
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Keynote Speaker, Dori Tunstall.

The closing Keynote was given by Dori Tunstall (@Dori_Danthro) presenting how OCAD U are continuing to decolonise their curriculum and implement Respectful Design across their studios and processes. Echoing Orr's Keynote observation, that the widening of design curricula must be a focus of design education in the coming years, Tunstall presented a positive and optimistic interpretation of how this can be achieved inclusively and without the 'race to the bottom' some may think it entails.

In between these keynotes were the usual range of interesting and well-researched presentations of papers, positions and works-in-progress from across the world. Anyone who has attended a LearnXDesign event will understand that it's usually a group of committed and passionate practitioners, coming together to share and expand their personal and collective knowledge in design education.



Conference organizer, Gary Pritchard.

In summing up the conference, Ravensbourne's Gary Pritchard and Linda Drew reflected what delegates were thinking - it was, as always, the people who made the event.

Hence, it is a great opportunity to thank everyone who contributed to the organisation: Dr Gary Pritchard, Professor Linda Drew, Professor Michael Tovey, Dr Alison James, Professor Susan Orr, Dr Rosemary Stott, Professor Bernadette Blair, Professor Alison Shreeve, and Professor Kay Stables.

The conference proceedings can be found on the DRS EdSIG page:

<https://www.designresearchsociety.org/cpages/design-pedagogy-sig>

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Chicago 2015 – Education and Design to Enlighten a Citizenry

3rd International Conference for Design Education Researchers

Robin VandeZande

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The 3rd International Conference for Design Education Researchers, “LearnXDesign2015” happened as a result of a conversation Erik Bohemia and I had in Oslo at the 2013 conference. I proposed that our organization, DESIGN-ED, partner with DRS and CUMULUS to host the future conference. The proposal was eventually accepted, and work began soon after.

The 2015 conference was hosted by the School of the Art Institute in Chicago. At the heart of the conference was a comprehensive engagement of topics across design pedagogy and research through presentations, workshops, and conversations. Delegates from 34 countries and 120 institutions attended and presented high standard scholarship on methodologies and concepts. Diverse topics were covered such as improving the world through design, exploring biomimicry, changing learning environments, strategizing teacher training, and exploring creativity.

The conference was a springboard for sharing ideas and concepts about contemporary design research and education. Contributors were invited to submit research that dealt with different facets of and approaches to design. Scholars proposed 389 abstract submissions for consideration. All submissions underwent a rigorous double blind review process, most often resulting in a re-write based on reviewers’ comments before being considered for inclusion in the conference and proceedings. Of all that was submitted, 119 research papers were selected to be presented at the conference, along with 23 workshops and 2 symposia.



Figure 1. Inclusion was inbuilt into the conference participation

Subject threads organized the schedule of presentations. The subject threads addressed the local and global



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multidimensional relations and interconnections of design education and design thinking with such diverse topics as nature, society, engineering, economics, media, and ecological urbanism. Academic and vocational curriculum development was presented in many sessions in reference to design as an integrative tool through a multidisciplinary philosophy to education. The delegates were able to follow a single thread, attending sequential sessions or could mix sessions to suit. The papers covered topics for educators in elementary, secondary, or higher education settings. Each presentation lasted twenty minutes followed by ten minutes of questions and/or discussion time. The most discussed aspect during the three days was that design should be used to improve life and the world.



Figure 2. A breakup group discussion over a lunch

The first keynote was a dialogue of three individuals who represented K-16 Design Education. They conversed

with each other and the audience members about their views on specific issues in design education. In order to get full involvement of the audience in the discussion, the reMesh app was used. reMesh is a chat platform where a crowd could take part in a conversation as if they were a single person, speaking with a single voice. Delegates were instructed in how to join the chat app that allowed everyone to offer an individual message and vote on other messages from the group in order to quickly and efficiently reach consensus. A prime motivation in the opening session was to inspire a dialogue about design and the world. The ultimate goal was to prompt the ad hoc creation of small groups interested in discussing particular issues further. Scenarios were developed and shared on a communal bulletin board and documented with the help of reMesh, over the course of the conference and post-conference.

As a follow-up to the debate session, there was a pop-up workshop. Participants in the workshop created a structure to encourage further dialogue on the topics that evolved from the keynote session. The pop-up structures were placed in strategic areas for delegates to interact with throughout the remainder of the conference. People were able to post ideas for others to build on, mapping the ideas that emerged and then spin-offs that occurred to people after the debate.

In addition to the conference participants, there were 35 young students involved in participatory workshops. The Think Make Share Design SLAM culminated with teen interns working for 20 hours to conceptualize, collaborate, envision, build and install, "What's Your Underground." A Chicago Tribune writer visited and was impressed with the videography, photography, smock making and desire of the teens to use design to explore what they care about and to reassure people that the future will be optimistic. Two Live Learning Labs immersed 4th graders who reimagined their school learning environments, building prototypes and collaborating on innovative experiences to motivate learning and teens in the topic of "What does Creativity Look Like?"



Figure 3. 4th graders who took part in the conference activities

A major theme of the conference centred on how our global community must change in a very fundamental way if it is to become stable. The question was asked: Why are these issues of concern for design educators worldwide?

Answers that emerged included: If we are to have a better world, the general populace has to build it, and if we are to be successful, everyone must take responsibility. Design thinking is an approach that everyone may learn in order to rethink assumptions by looking at our everyday world with a new perspective, challenging

what is possible, and reconsidering our relationship to things familiar. Design education is addressing the welfare of people and the environment, reflecting a renewed appreciation of and respect for nature. Sustainability is taught to show that it will improve our world through a less consumptive lifestyle, respect for the environment and the interdependence of life, creating safe objects for long-term use, and concentrating on communities and economic systems. There is attention being given to designing for improving the physical and emotional quality of life for everyone, referred to as universal design. Socially responsible design reflects the growing awareness of our finite resources and factors that are damaging to the environment as well as the realization that designed objects should have flexibility in order to be accessible to all. Design education brings all of this to the consciousness of students in order to show them ways to be empowered to do something constructive to help.

A promotional poster for the LearnxDesign 2015 conference. The poster features a central blue rectangular area with white text. To the left of this area is a vertical strip showing a view of the Chicago skyline from the water. To the right is a vertical strip showing a large crowd of people walking along a path in Millennium Park, with the Chicago skyline in the background. The text on the blue background includes the location and dates, the event name, a subtitle, a list of activities, a description of the conference, and a website link.

Chicago, IL USA / June 28-30 2015

LearnxDesign

*The 3rd International Conference for Design Education
Researchers and PreK-16 Design Educators*

Millennium Park, The Art Institute, Navy Pier,
Architectural boat tours. It's summer in Chicago!

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from as many as 40 countries will convene in Chicago
to navigate the extraordinary possibilities of design and
education. Come join this unique conference as we all
engage in the exchange of experiences, insights, and
inspirations for Learning by Design!

Find out more at:
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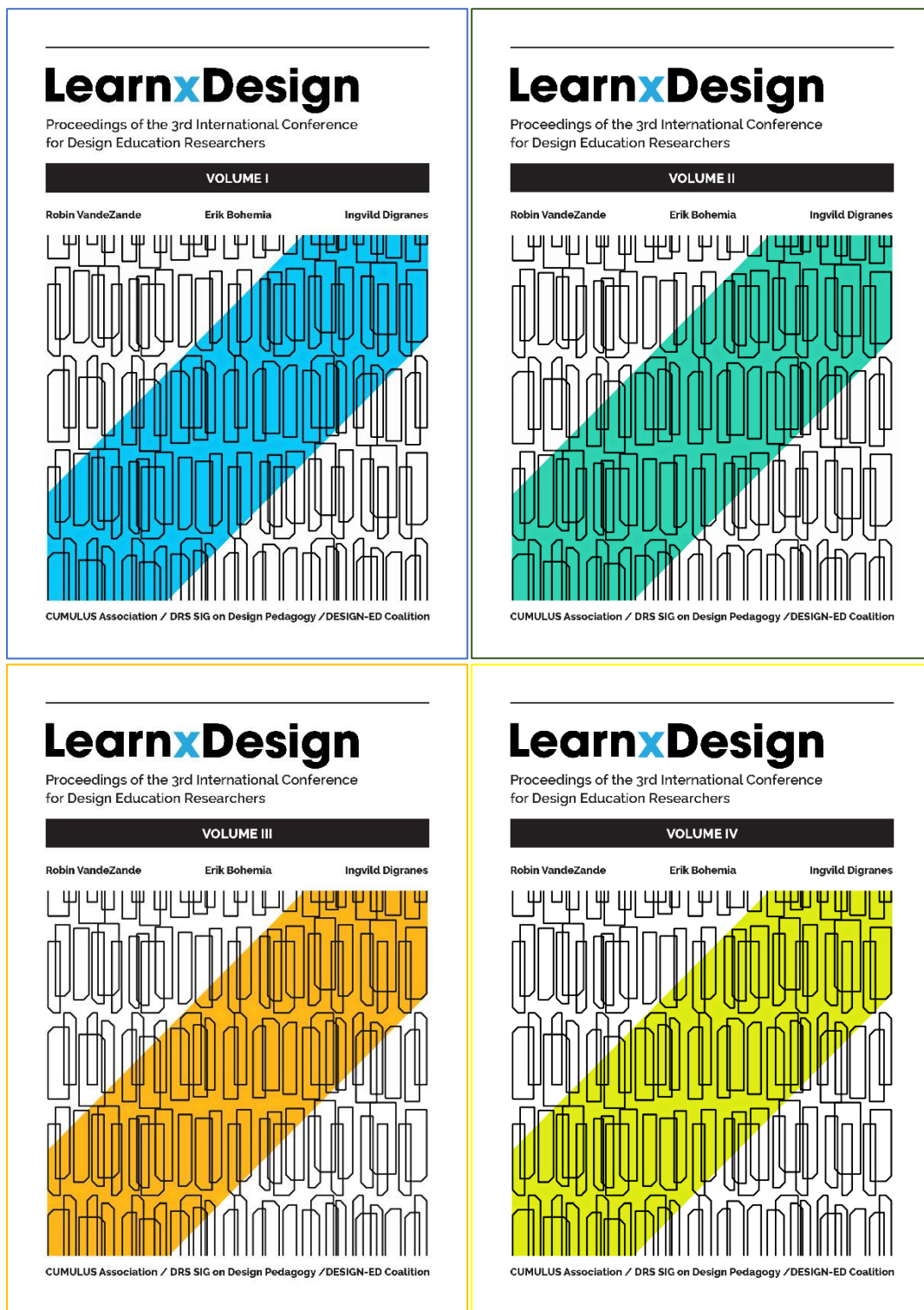


Figure 4. Four volumes of the 2015 conference proceedings

Other highlights of the conference included the South Side Chicago Bus Tour narrated by two designers, an architectural boat cruise reception, a keynote talk about art, science and design, visual note taking posters, green city/greens schools and nature play workshops, ongoing research labs and Victor Margolin's Life-Time Achievement Award keynote speech and celebration dinner at a beautiful venue overlooking the city of Chicago.



Figure 5. Victor Margolin was presented by Ingvild and Robin with an award for his contribution to the design field

Although I might be successful in providing the “flavor” of the 2015 Conference in this short essay, it is difficult to capture those enthusiastic conversations that followed presentations and spilled into the hallways and receptions. I cannot articulate the “community” spirit where a group of individuals explored new ideas and cultivated collaboration during and after the event. I cannot invoke those inspiring moments of sharing stories and asking questions; the chance to challenge and be challenged, and were learning together fuelled motivation.



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VandeZande, chair of Learn X Design 2015, Chicago, IL, is professor/coordinator of art/design education. Her activism assisted in the inclusion of design in the US national art education standards (2014). VandeZande has received many awards, notably Distinguished Fellow (NAEA), National Art Education Higher Educator (NAEA), and President's Faculty Excellence (KSU). She was a featured speaker for 60 national/state events. Her books include *Design Education: Creating Thinkers to Improve the World* (2016) and co-authored *Fashion Fundamentals* (2020).

Oslo 2013 – Design Learning for Tomorrow

Reflections on the 2nd International Conference for Design Education Researchers

Liv Merete Nielsen

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The 2nd International Conference for Design Education Researchers was arranged 14-17th of May 2013 at Oslo and Akershus University College of Applied Sciences (now Oslo Metropolitan University). The thematic focus was *Design Learning for Tomorrow. Design Education from Kindergarten to PhD*, and it attracted 278 delegates from 43 countries. Researchers from more than 74 universities conducted a rigorous, double-blind review process of 225 full papers, from which 165 were selected for presentation at the conference and included in the four volumes of conference proceedings (Reitan et al., 2013). After the conference some papers were further developed and published in special issues of journals, including *FormAkademisk*; *Art, Design & Communication in Higher Education*; *TechneA*; *Design and Technology Education* and *Studies in Material Thinking*.



Figure 1. The first evenings 'come together' included an exhibition of chairs design by Peter Opsvik and Terje Ekstrøm.
Photo: Blæsterdalen



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Figure 2. Meeting colleagues. Photo: Blæsterdalen

Design learning for tomorrow – building design literacy

The conference theme, design learning for tomorrow, was challenging. With the strap line 'Design Education from Kindergarten to PhD', it was possible to embrace a broad interdisciplinary approach. With the underlying idea that sustainable design solutions should include both professional designers and the general public, cooperation was at the core. Real cooperation demands however some kind of common understanding. From the perspective of moving in the direction of a greener and better tomorrow, design should also be included as a core component of general education. Educating the general public to be 'conscious' consumers and decision makers with responsibility for quality and longevity, was seen as a way out of a 'throw-away' society. The importance of moving education and research in the direction of a better and greener tomorrow was of particular focus. The high profiled keynote speakers contributed with advanced insight on the conference theme, among them professors Halina Dunin-Woyseth, Fredrik Nilsson, Tim Cooper, Jim Gleeson, Jill Franz, Ingvild Digranes and Astrid Skjerven.

In the call for the 2013 Oslo conference, we invited papers dealing with design education from the kindergarten to PhD levels, especially those that included design education for the general public in schools. In their positions as consumers and decision makers, the general public has great potential power to refuse to buy things they do not need and to promote the movement toward longer lasting, locally made products. Since 2013, young people's interest in securing a greener tomorrow has expanded, as can be seen with the rise of, among others, Greta Thunberg.

The papers from the conference contributed to building our knowledge of design education challenges around the world. The following ten tracks, including the numbers of approved papers in each of them, indicates interest from researchers within the design research community.

- Philosophy of design education (18)
- Design curriculum (19)
- Design knowledge (17)
- Design education for non-designers (26)
- Research informed designed education – Design education informing research (18)
- Multidisciplinary design education (18)
- Challenges in design education methods (31)
- Assessment (8)
- eLearning and Design Education (5)
- Internationalisation of Design Education (5)

It was no surprise that the track with the most papers was *Challenges in design education methods*. Education has, for far too long, been associated with different educational methods. All education is rooted in a philosophical meta level, but such ideas are not always clearly articulated and discussed. Often, the philosophy of design education is unarticulated as a hidden value, and unarticulated traditions and values in design education have the potential to confuse educational discussions across different cultures.

As the call for the conference was focusing on design education for non-designers, it was no surprise that the track of the same name had 26 papers presented. This inclusion of non-designers and the general public was fortuitous for the Norwegian organisers who had been promoting such ideas for many years. It was nice to see how these thoughts were accepted in the design research community and have been followed up at the coming DRS Learn X Design's, but also at other design conferences, such as *Engineering and Product Design Education* (E&PDE Oslo 2017), *Design Research Society* (DRS Limerick 2018) and *Academy for Design Innovation Management* (ADIM London 2019).

Issues related to consumption and environmental challenges are at the core of design; therefore, they are also at the heart of design education. But we all know that designers need to find jobs, and increased consumption has traditionally been more important for companies than producing longer-lasting products and promoting slow consumption. As long as economy rules, designers will neither have the position nor power to change consumption patterns to make them greener and slower. Consumption is, however, dependent on consumers—and consumers have potential power. Educating the general public on design has emerged from this perspective. When Joanna Boehnert reviewed the conference, she concluded: 'Overall this conference was a timely reminder of the importance of making time for research to strategically address challenges facing design education' (2013).

In 2013, cooperation between DRS and CUMULUS (the International Association for Universities and Colleges of Art, Design and Media), was on the agenda, and the agreement was signed in Oslo. This is mirrored in the logo for the Oslo conference, 'DRS//cumulus Oslo 2013'. The next conference, in Chicago, introduced, LearnXdesign as title.

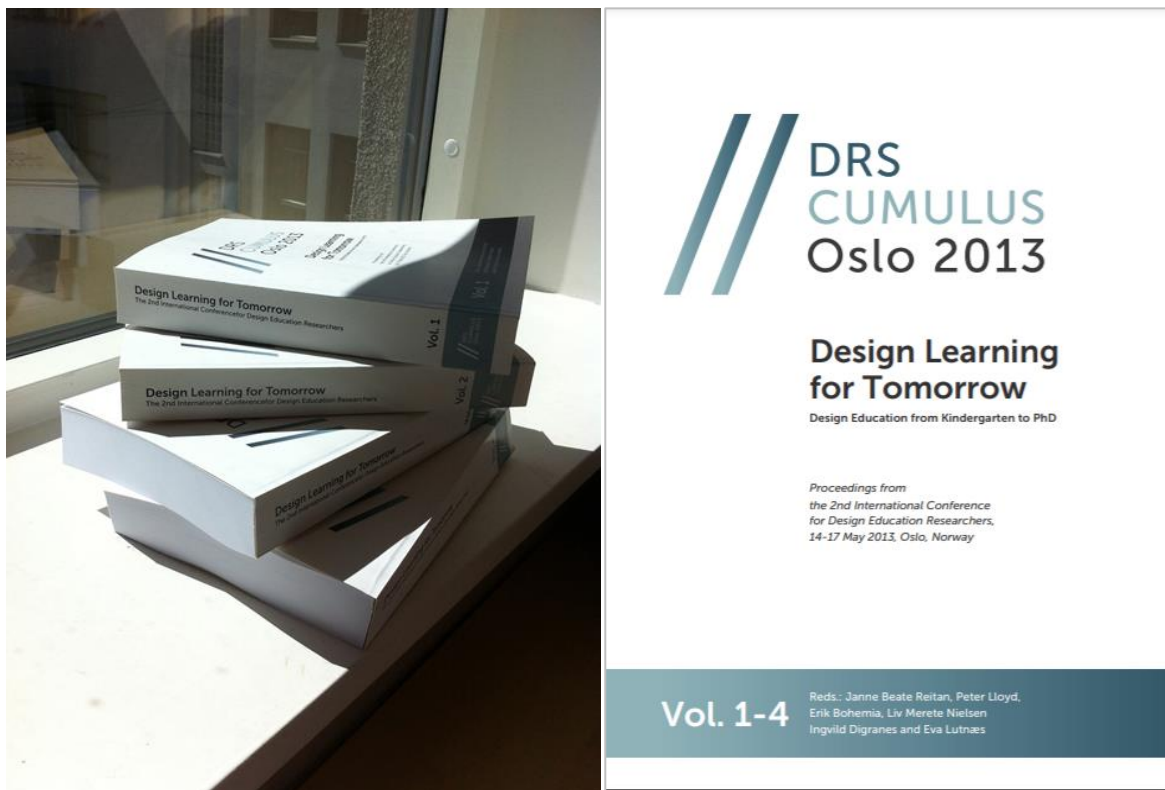


Figure 6. The four volumes of the conference proceedings are available at the conference webpage <https://uni.oslomet.no/drscumulusoslo2013/> and at the DRS digital Library <https://dl.designresearchsociety.org/learnxdesign/> Photo: Reitan

Workshops and social interactions

There were seven workshops held on the first day of the Oslo conference. The value of these workshops should not be underestimated, as small groups encourage closer relations and deeper discussions. Their outcomes are friendship and cooperation across borders. Sometimes, outcomes include common applications for funding and research projects. The topics of the workshops in 2013 were:

- Design history in the design education curriculum
- Defining goals through collaboration using design thinking: Project team building consensus
- What is/could/should a design PhD be?
- What can K-12 age students learn from designers about promoting social responsibility and improving the economy?
- Assessment criteria that meet an internationalisation agenda
- Deep diving with design students: Using immersive, participatory design as a tool for generating design solutions
- Design Literacy - from primary education to university level. Applying for EU funding for the project

The Design Literacy workshop (Nielsen & Brænne, 2013) might serve as an example of how international researchers can meet and continue to develop the field of design knowledge. In 2019, some of the same researchers from this 2013 conference established the *Design Literacy International Network* (DLIN). This network gathers design education researchers for digital events on the first Tuesday of every month. Under the title 'Engage with ideas', researchers from all around the world meet virtually to share ideas in which they are engaged. This provides a sense of continuity, and sometimes we are able to get deeper into the philosophy of design education.

Besides workshops the conference included opportunities for social interaction during breaks, a 'come together' the first evening, reception at *Oslo Town Hall*, exhibition at *Norsk Form*, visit at the sculpture park, *Vigelandsparken*, and a conference dinner by the sea at *Aker Brygge*.

A touch of 17th of May in Oslo

The final day of the conference was the 17 May, which is a very special date for all Norwegians. We celebrate our independence with a children's parade up to the Royal Castle. The conference location was close to the castle, so all the delegates could move out onto the streets to watch the children and parents in their national costumes. Hopefully, this was a memorable day for all in attendance.



Figure 4. Members of the Programme committee; Ingvild Digranes (left) and Janne Beate Reitan (right) dressed up in their national costumes on the 17th of May - the last day of the conference. The rest of us enjoyed the ending of a nice conference. Photo: Blæsterdalen.

Thanks to Design Research Society

My colleague, Janne Beate Reitan, and I were determined to participate when the 1st International Conference for Design Education Researchers was arranged in Paris in 2011. We had been looking for international arenas where design education research was at the core. In Paris, we met with conference chair Erik Bohemia,

Michael Tovey, leader of DRS/PedSIG and Peter Lloyd, now chair of DRS, and we expressed our interest in arranging the next conference. Lucky for us, we were entrusted to host the 2nd International Conference for Design Education Researchers in Oslo 2013. However, we could not have managed without help from Erik and Peter. Peter agreed to serve as the chair of the scientific committee, and Erik was co-chair for the whole conference. They were both involved as editors of the proceedings. I would also like to thank Janne Beate Reitan, Ingvild Digranes and Eva Lutnæs at Oslo Metropolitan University (former Oslo and Akershus University College of Applied Sciences) for their great effort before, under and after the conference. Thank you.

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Chair of the DRS//cumulus Oslo 2013 conference and chair of the International Scientific Programme Committee of DRS LearnXdesign, Jinan 2021. Nielsen is professor emerita at OsloMet. She is the founder of Design Literacy International Network (DLIN) and a member of the convening group for EdSIG/DRS. She has had a leading role in developing national curricula for design, art and craft. Nielsen is honorary member for the national organisation *Art & design in education*. She is editor and author for several books and journals.

Paris 2011 – Researching Design Education

The initiation of the international conference series

Erik Bohemia

https://doi.org/10.21606/drs_lxd2021.11.377

Introduction

Number of events led to development of the International Conference for Design Education Researchers. One of these was declaration by the Design School's Dean where I used to work that academics in design field should not be perusing design education research. I felt this was poorly conceived idea as most design academics are concerned about their students learning and thus would be motivated to become introduced to practice research to evidence their 'good' pedagogical practices. Second was realisation that, in the UK, design education research was seen as uncritical and thus trivial by the Research Exercise Review Panel members and the third was my impatience with the Design Research Society, after I joined its Council, to provide a platform for design education researchers to improve their research practices. The idea for a general design education research conference was also informed by having an opportunity to chair the 9th International Conference on Engineering and Product Design Educational (E&PDE) conference (Bohemia et al., 2007). The chairing 2007 E&PDE provided me with an insight on how the Design Society used the E&PDE to develop its flagship ICED conferences. The unlike large conferences which can be intimidating the E&PDE conference supported design academics to become familiar for the first time with academic conference format in a friendly community setting.

Getting the event through the DRS Council was over two years long, bumpy and onerous journey. And it was not until I was able to get the CUMULUS association on board that the DRS Council members reluctantly agreed to let the event to go ahead.

Decade later from when the 1st event was staged, the DRS Learn X Design conference is now established as the key platform for the Design Research Society's Design Education SIG to disseminate research related to Design Education getting the members.

The 1st International Symposium for Design Education Researchers took place in Paris, France on 18–19 May 2011. The Symposium was held under the auspices of the Design Research Society's Design Pedagogy Special Interest Group and CUMULUS which the International Association of Universities and Colleges of Art and Design.

Beside the reasons outlined above, one of the aims of the symposium was to develop and to establish relationships between CUMULUS and DRS Design Pedagogy Special Interest Group. The idea was to bring members from these two societies and strengthen the capacity to enhance the quality of design education through examining how innovation in education is informed by and is informing design research.

To do this, together with Brigitte Borja de Mozota, from the hosting institution and Luisa Collina from CUMULUS, we have invited a diverse mix of speakers experienced academics to explore the symposium's broad theme of *Researching Design Education*. Initially, the invited speakers submitted brief proposals. Then they submitted full papers which were critically double-blind peer reviewed by members of the International Scientific Review Committee. The revised 12 accepted papers, 3 keynotes and an editorial formed the symposium's proceedings.

The presenters came from different disciplinary backgrounds and different countries, including the Netherlands, the UK, France, Switzerland, Finland, and Italy. The outcome was a symposium that tackled diverse design education issues from a variety of perspectives, both disciplinary and institutional.

An intensive poster seminar session with seventeen PhD candidates was the opening activity for the



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symposium.



Figure 1. The 1st International Symposium for Design Education Researchers was held in the Paris Bourse Exchange building



Figure 2. One hundred delegates attended the 2011 symposium.

The keynotes were delivered by Ezio Manzini, Bridget Borja De Mozota and Andy Polaine. Ezio Manzini delivered his keynote via Skype from his home, which at that time was a novel way to organise a keynote delivery (see Figure 2). In his address, Enzo stated that design schools have a greater agency as they can operate with greater degrees of freedom than commercial design agencies and thus potentially could deliver more innovative solutions (Manzini, 2011).



Figure 3. Proceedings cover page designed by Samantha Schulman. On the right, a poster template.



Figure 4. Ezio Manzini delivered his keynote via Skype.

Polaine (2011, p. 59) in his address argued that:

Despite the rhetoric of interdisciplinarity, design research and design education research have become too convergent and discipline specific. Much like the towers of medieval San Gimignano, academic careers are built by adding layers to one's own discipline tower while attempting to demolish those of others. Trying to prove ourselves wrong may seem counter-intuitive to a field that is trying to gain credibility outside of its usual place in the food-chain, but it is also the mark of self-confidence.

Borja De Mozota (2011, p. 25) in her keynote titled *Design Economics—Microeconomics and Macroeconomics: Exploring the Value of Designers' Skills in Our 21st Century Economy* (see Figure 3 and Figure 4) suggested that:

Design consultancies do not have the same power to change the view of design in the foundations of

management science and organization theory. An outside designer is a consultant working within the budget and under the authority of another organizational function, most frequently R&D or communications or marketing.

She proposed that the design education have to be active in reinventing the Design guilds for designers to “become more effective entrepreneurs in order to help society at large to face the changes in this transitional period between two socio-technical systems. They also have to design their profession as a part of the creative industries.” (Borja De Mozota, 2011, p. 38)



Figure 5. Brigitte Borja De Mozota delivering her keynote address

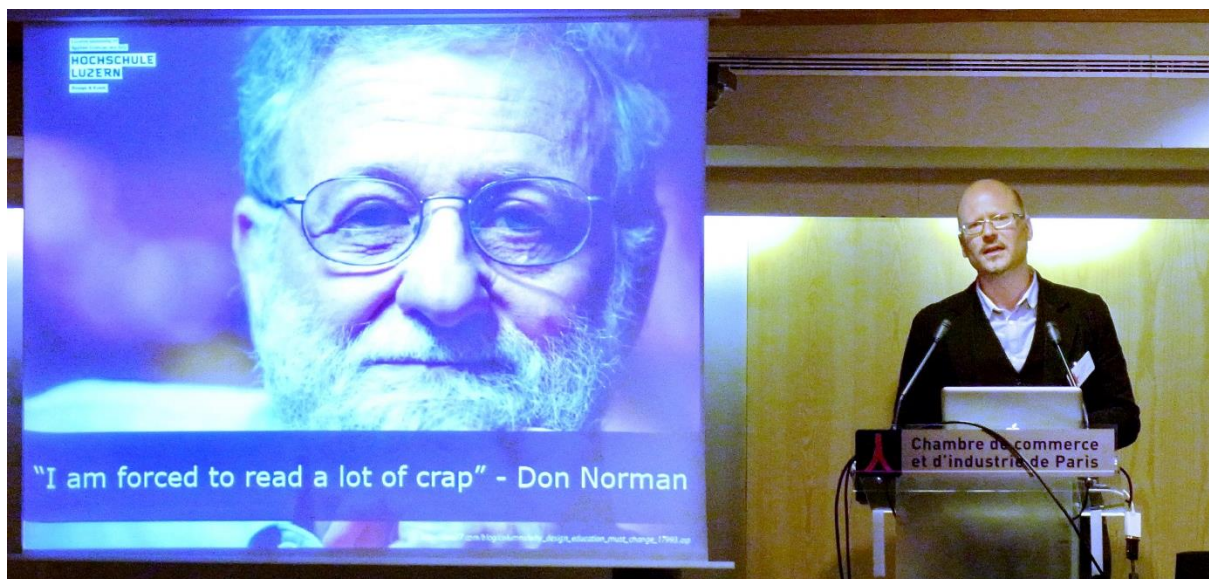


Figure 6. Andy Polaine who delivered the keynote address titled “Design for General Education”

CUMULUS Association and DRS Design Pedagogy Special Interest Group coming together signalled the increased importance of re-examining design education in these changing times. The two associations signed a

collaborative agreement at the 2013 Oslo conference. For example, CUMULUS Association and DRS Design Pedagogy Special Interest Group are planning to organise a joint international conference in 2013. The more immediate plan is to produce a Special Issue of 'Collection', a research journal on the theme of 'Informing Design Education by Research' from selected papers presented at the symposium. Another set of papers will be selected for an edited book on the theme of 'Researching Design Education'.

Number of people and organisations have been helpful in organising the symposium and preparing the set of proceedings. These include Christian Guellerin President of Cumulus and Michael Tovey the conveyor of DRS PedSIG (see Figure 4).



Figure 8. Elvin Karana, Peter Lloyd and Kath McKelvey listening one of the presentations.



Figure 9. Alisin Shreeve discusses possibility of design education to lose its character.



Figure 9. Jacques Leroux from the Paris Chamber of Commerce and Industry opening the symposium. Michael Tovey the conveyor of DRS PedSIG and Christian Guellerin President of Cumulus are seated on the podium.

Jacques Leroux (see Figure 4) from the Paris Chamber of Commerce and Industry and his colleagues and team who kindly provided the venue and made the symposium delegates welcome; the team from CUMULUS Association Eija Salmi and Justyna Maciak (see Figure 5) based at Aalto University.



Figure 10. Justyna Maciak and Geneviève Sengissenat; Christian Guellerin President of Cumulus with Brigitte Borja De Mozota who co-edited the proceedings

Geneviève Sengissen and Pascale Labé and their team based at L'École de Design Nantes Atlantique who provided the logistics; Anne Schoonbrodt and Alessandro Biamonti for organising the poster session; Deborah Wickham from L'École Parsons à Paris who encourage her students to produce artwork proposals for this proceedings, Samantha Schulman and Tanya Benet whose design proposals were adopted and every member of the International Scientific Review Committee who provided their time and expertise during the review

process.



Figure 11. Geneviève Sengissenat who was instrumental to managed planning and organising the local logistics



Figure 12. The conference delegates continued their discussion over the lunch

This was a truly international team effort by symposium committee whose members from DRS and CUMULUS Association were dispersed across European universities. These included Aalto University, L'École de Design Nantes Atlantique, Coventry University, L'École Parsons à Paris; Northumbria University and Politecnico di Milano.

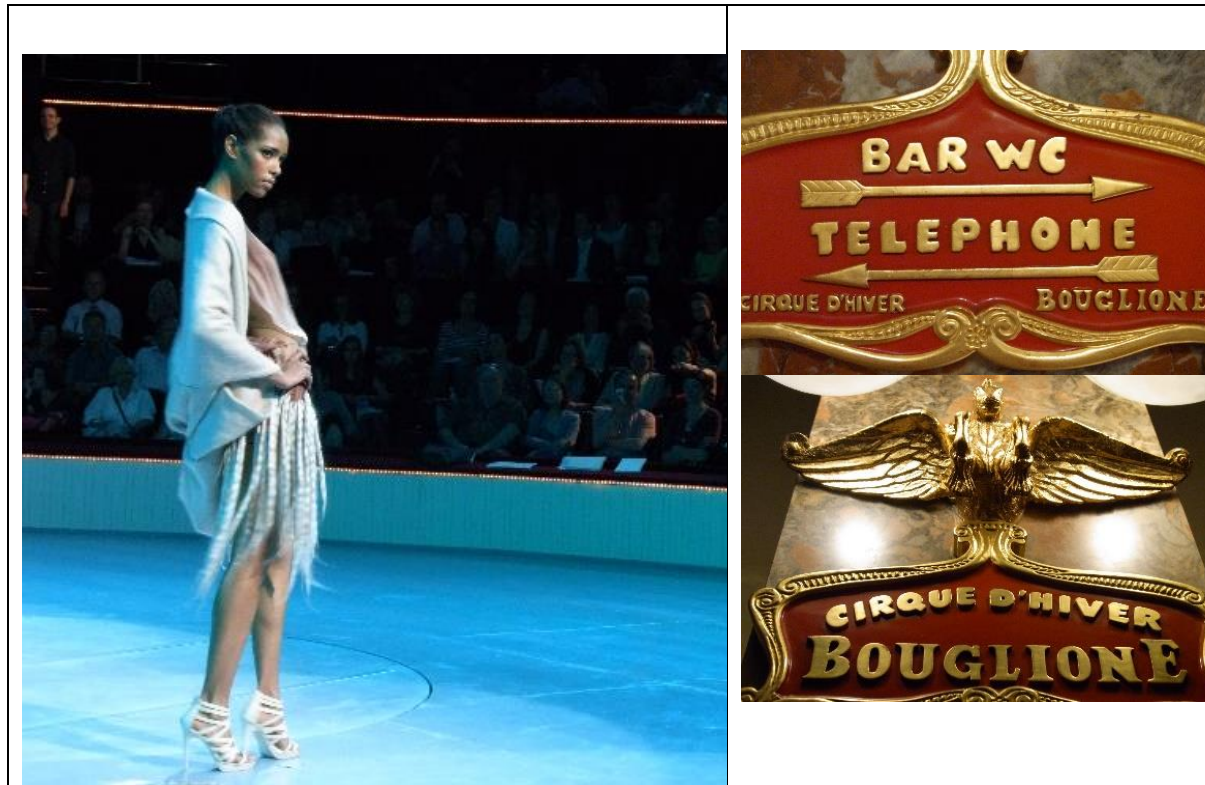


Figure 13. Attending a fashion show was a highlight

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Dr Bohemia's ongoing research is in the broad area of 'Materialities of Designing' with focus on how cultural elements are shaping designers' approaches. He has co-chaired over 20 key international academic conferences with international societies such as the Design Institute Management (DMI); Academy for Design Innovation Management (ADIM); Design Research Society (DRS) and Design Society (DS).



Section 01

Design Thinking to Improve Creative Problem-solving: From Kindergarten to Higher Education

Track 01: Design Thinking to Improve Creative Problem Solving

From Kindergarten to Higher Education

Úrsula Bravo, Catalina Cortés, Jeannette LaFors, Fabio Andres Tellez and Natalia Allende
https://doi.org/10.21606/drs_lxd2021.00.315

As educators increasingly adopt design-based methods outside of design disciplines, we wondered about the impact of incorporating these approaches on students' and teachers' educative experiences. This track includes eleven articles that explore how children, youth, and teachers in schools and universities have taken up design thinking and other design-based models. The track also offers two design-based teaching models presented as workshops. In the following text, we present arguments that justify the incorporation of design in general education –both at the school and university level–, synthesize some empirical evidence from the scientific literature, present the contributions gathered in our track, and offer some questions to guide future research.

Keywords: design thinking, design-based teaching and learning, general education

According to the Nobel Laureate in Economics Herbert Simon (1996), when any professionals carry out actions tending to change existing situations into preferred ones, they are involved in design. In this sense, design would be the core of all professional training and the element that distinguishes the professions and the sciences. In the same line, Donald Schön (1983) suggested that despite the differences between the various professional activities, there is a generic process underlying all professions that deal with solving complex problems. For him, activities such as architecture (and, of course, design) could serve as a prototype for other professionals to develop problem-framing skills. Perhaps this would explain the proliferation of methods and tools based on design applied to professional areas such as business, management, healthcare, and education. During the last decade, design has gained popularity to address complex problems and foster innovation in different contexts, including general educational settings. In fact, a growing number of academic and professional publications have reported diverse experiences where design-based methods and tools are used to address pedagogical issues, both at the K-12 (Gallagher & Thordarson, 2018; Goldman & Kabayadondo, 2017; Koh et al., 2015; McIntosh, 2016) and the higher education levels (Dunne & Martin, 2006; Hassi & Laakso, 2011; Martin & Martin, 2009; McLaughlan & Lodge, 2019; Revano & Garcia, 2020; Vaugh et al., 2020). Some examples of design-based methods are Design Thinking for Educators toolkit (IDEO, 2012), Design for Change (Allende, 2016; Design for Change, 2017), The Compass (Stenlev & Boegeskov, 2016), and FabLab Teacher Studio (Watson, 2015). At the higher education level, the Open University's distance Design Thinking (U101) course stands out since 2010 aimed at students of different ages and professional and educational backgrounds (Lloyd & Jones, 2013).

To better understand the enthusiasm that design provokes in general education, it is worth recalling what Nigel Cross pointed out in 1982, many years before these models attempted to replicate inside schools the way designers, engineers, and architects think and solve complex problems. In his paper entitled "Designerly ways of knowing", Cross advocated for incorporating design into general education together with sciences and humanities, arguing that design develops innate abilities in solving ill-defined problems, sustains concrete and visual modes of cognition, and offers opportunities for developing a wide range of nonverbal thoughts and communication abilities. In the same way, the Open University began offering courses on design in 1975



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seeking to teach students about design and the design process as a general phenomenon, but not as a profession (Lloyd, 2013). More than thirty years after Cross' article, the interest in incorporating design into general education remained, but the expectations widened by including a critical and sustainable approach. The DRS // Cumulus Conference in 2013 at Oslo promoted the cooperation between designers and the general public as a precondition to building a better and greener tomorrow and fostered teaching a critical design approach among consumers, producers, and decision-makers (Nielsen, 2013).

Design-based teaching and learning in school settings

Nowadays, design-based learning has been described as a learning-by-doing methodology that enables students to integrate knowledge from different areas through problem-solving. It is used both in technology-related subjects –such as STEM, informatics, and Maker education– and in other areas of the curriculum. It aims to develop both thinking skills –such as problem-solving, inquiry, and creativity– and socio-emotional skills –such as empathy, collaboration, self-efficacy, and frustration tolerance– by embracing ‘failure’ as part of the learning experience (Carroll et al., 2010; Carroll, 2015; Davis, 2004, 2017; Retna, 2016; Woo et al., 2017; Zupan et al., 2018). According to Goldman and Kabayadondo (2017), it has the power to flip students’ mindsets from passive and tentative toward active and decisive.

In school settings, design thinking can operate both as a methodology to ground students’ learning and help teachers think through issues of practice. According to Goodyear (2015), unlike the classical instructional design, which focuses on optimizing instruction for a single or simple objective, the design for learning approach is characterized by broadening the understanding of the problem to see it as a symptom of a larger issue. At the initial teacher training level, Jordan (2016) has suggested that a design-based approach enables teachers to be more flexible, adaptive, and open to exploring. At the same time, Henriksen (2017) has observed that design thinking provides an accessible structure that enables school teachers to creatively face the great variety of problems that they must solve daily. In the same way, Goldman and collaborators (2020) have observed that using tools based on design thinking helps educators to think holistically about the special educational needs of their students. Also, at the school level, but from an organizational perspective, Mintrop, Órdenes, and Madero (2018) suggest that design-based approaches have the virtue of integrating improvement dynamics from outside the school –such as new education policies– with school improvement initiatives coming from teachers and school leaders. For them, design-based school improvement follows the logic of continuous enhancement.

The following two articles present experiences in a school context, while the third refers to a teacher professional development program for inclusive education at schools. All of them feature student learning needs as both the starting and ending point in a productive design thinking process. In addition, all three suggest that instructional designers –whether young people, teachers, curriculum developers, or teachers in training– can leverage the design thinking process to deepen learners’ knowledge and skills.

The first paper, entitled **“End Users in Students’ Participatory Design Process”** by Noora Bosch, Tellervo Härkki, and Pirta Seitamaa-Hakkarainen, offers fascinating insights into how young designers (ages 14 and 15 years old female students from a public secondary school) took stock of their end-users’ (16 kindergarten students and their two teachers at a nearby elementary school) wishes and needs as they developed a specific product for them. Over a three-month period, the teen designers from two teams designed, prototyped, and tested their ideas for e-textile creations. The researchers’ captured how the teen designers determined and acted upon their end-users’ requirements. Specifically, they asked, “What kind of end-user-related design discussions did the students have?” And, “In which way are the end-users or their stated needs, wishes, and feedback acknowledged in the final design products?” The researchers documented design discussions related to various functional, technical, and visual/aesthetic features, and traced back many features and solutions (both concrete & abstract) of the final products to the users’ stated and/or presumed needs. The researchers conclude that the concrete direct contact that the teen designers had with their kindergarten clients was instrumental in both the process and the product outcomes, and they encourage further research documenting student development of design skills such as empathy, creativity, communication, and collaboration.

The second contribution, **“Integrating Design Thinking into STEAM Education: The Design of STEAM Education Platform and Course Based on Creativity Elements”** by Xuejiao Yin, Shumeng Hou, and Qingxuan Chen, addresses the knowledge and skills that students might develop through design thinking-based learning platforms. This paper presents evidence that design thinking promotes deep and meaningful learning for students, and three dimensions of creativity in particular – curiosity, flexibility, and risk-taking – which the authors link to positive learning outcomes. One hundred fifty-one school-age children (10–12 years old) from

Shenzhen, China participated in the study which involved engaging in several online Science, Technology, Engineering, Art and Mathematics (STEAM) instructional modules (based on the Design for Change model) and a battery of assessments to measure student creativity, self-efficacy, and academic performance. This study has important implications for ways young people might effectively learn particular anchor skills related to design thinking. Furthermore, this study suggests that the integration of STEAM education and design thinking could push on the traditional ways we conceive of and represent knowledge and skills.

The third offering, Úrsula Bravo and Maritza Rivera's paper, **"Inclusive education driven by design: The case of a graduate seminar course"**, is a rich qualitative case study describing how the course's driving question, "How can a design-based approach contribute to the development of strategies for inclusive education?" played out with educators and their focus students. Thirty-five educators in their last year of a master's degree focused on inclusive education participated in the study, and the researchers selected three specific examples to illustrate how the interdisciplinary design thinking approach to frame and address students' special learning needs unfolded through the use of various design tools. This study shows how teachers might tackle a wide variety of complex problems through a design process that puts the student and their learning needs at the center and relies on educators as active agents capable of visualizing, supporting, and reflecting on a learning process that will benefit the student in a particular context.

Design-based teaching and learning in Higher Education

At the higher education level Meredith Davis (1998, 2004, 2017) has demonstrated the value that design-based teaching and learning practices have to promote critical and creative thinking, as well as many other "twenty-first century skills" (e.g., problem-solving, communication, collaboration) essential to tackling the large, complex, and systemic challenges facing humanity. Additionally, Davis has shown that educators in different fields, "when presented with concrete [design-based] teaching strategies, can adapt design approaches to disciplinary content to achieve the higher-order thinking skills demanded by a knowledge economy" (2017, p. 169). Expanding the scope of skills developed through design-based learning, Goldman and colleagues (2012), have proposed that adult learners, as they become design thinkers, change their behaviour and mental structures in four distinct ways (what the authors call "Design Thinking Mindshifts"): learners become "human-centered, experimental, collaborative, and metacognitive" (p. 30).

Design-based teaching and learning at general professional training

The following four articles explore and expand on ideas from the literature on design-based teaching and learning and contribute to our track through a series of reflections, empirical studies, and innovations in the classroom. In particular, these articles explore the integration of Human-Centered Design approaches in higher education courses; study the use of design thinking methods to promote effective and meaningful learning; investigate the concept of "grit" and how to promote it in the academic design studio; and propose new design-based approaches to higher education to equip students with the skills, knowledge, and perspectives to thrive in a volatile, uncertain, complex, and ambiguous world.

In the paper **"Measuring the Impact of Integrating Human-Centered Design in Existing Higher Education Courses"**, the authors Saadeddine Shehab and Carol Guo introduce and discuss a survey intended to measure the impact of integrating Human-Centered Design (HCD) on students' knowledge of performing the HCD processes. By presenting this survey, the authors intend to promote the integration of Human-Centered Design in higher education courses by providing an effective tool to measure the impact of these interventions on students' skills and knowledge. By pursuing this goal, Shehab and Guo make an important contribution to our track, which is intended to improve our understanding of the impact of incorporating design thinking and design-based practices on students' learning experiences.

The following contribution is from Juan Li, Shuo-Fang Liu, Meng-xun Ho, and Zhe Li. Their paper is entitled: **"Assessing Learning Performance and Using Preference of Design Thinking Methods in Graduate Interdisciplinary Online Course"**. Juan Li and colleagues explore the application of four widely used design methods in an interdisciplinary online course for graduate students from two prominent universities in China and Japan. The methods implemented in different moments of the course and studied by the authors include Brainstorming, Crazy8, User Journey Mapping, and Storyboarding. Through a series of quantitative analyses, the authors find that Brainstorming and Storyboarding improve students' learning performance in the analyzed educational context. In conclusion, the authors suggest that applying some design thinking methods in graduate interdisciplinary online courses is feasible and promotes effective learning practices. In their paper, Juan Li and colleagues contribute to our track by addressing a question that explores the experience of educators, that is, "which design-based teaching methods have been most effective for teachers, in what areas

of the curriculum, and at what educational levels?”

The paper submitted by Zhengping Liow is entitled **“I Can and I Will: A Study of ‘Grit’ in a Collaborative Team Learning Studio Pedagogical Cultures”**. This paper explores the concept of ‘grit’ (passion and perseverance for long-term goals) as a predictor for academic success in an architecture program. The paper presents a three-year longitudinal study comparing the capacity to instill grit of two different pedagogical approaches. The study compared the students’ level of grit in two groups exposed to CTL (Collaborative Team Learning, considered a heterarchical pedagogy) and to OOO (One-on-One, considered an authoritarian pedagogy). Through a series of statistical analyses, the researchers determined that there was little correlation between students’ level of grit with academic scores and the two pedagogical approaches implemented. To conclude, the author discusses potential causes for obtaining these results, emphasizes the problematic nature of tutor-centered practices in design education, and highlights the importance of continuing the study of heterarchical pedagogies from both a qualitative and a quantitative approach. Even though the scope of this paper goes beyond the questions posed for our track, it investigates the construct of grit and has received limited attention in design education. Additionally, the article poses very interesting, pertinent, and timely questions and reflections about design pedagogies in the face of an ever-changing world and an increasingly uncertain future.

Kirsten Bonde Sørensen provides a paper entitled **“Nordic Life Design: A holistic approach and attitude to life”**. The article discusses the need for new and more holistic approaches to higher education in the face of the challenges posed to newer generations of students by a complex reality and by increasing mental health issues. Specifically, the author presents and describes the Nordic Life Design as a “learning concept that aims at helping and empowering students to become better prepared for a complex, ambiguous and ever-changing world... [and] at enlarging students’ perspectives and relationships to others and to themselves.” According to the author, at the core of this concept lies the idea that students need both life mastery skills and concrete knowledge to deal with the VUCA world (an acronym describing the world as Volatile, Uncertain, Complex, and Ambiguous), and that life is a creative learning process that can be designed and co-designed by people. The author illustrates and exemplifies this concept with a series of educational experiences in which the Nordic Life Design was implemented and in which the reactions and opinions of students were collected. In conclusion, Sørensen offers a series of recommendations and invitations for educators to expand the scope of their curricula so that they offer students the skills they need to thrive in an ever-changing world.

Design disciplines professional training

Particularly in professional training related to creative and project-based disciplines, the design thinking approach has contributed to enrich each of the phases and deepen the development of a problem-solving mentality. The following four articles present research on fundamental aspects of the design process and tools that can be applied to enhance creative problem-solving. The main topics addressed are: generating iterative ideation through a Creative Problem-Solving Course, using morphological analysis to assess products, applying a specific design model to guide students to address both consumers and the enterprise during their design processes, and using a design model based on Bloom's Taxonomy to keep the product's inherent characteristics and users' demands present while designing.

The paper **“Different Ideas, Lots of Ideas: A design course that enhances the creative abilities of college students”**, written by Jody Nyboer and Brad Hokanson, frames the concept of creativity through relevant and up-to-date literature about the benefits, methods, and limitations to develop this fundamental skill. It focuses on learning creative thinking in higher education to face the world of work and life in general. The paper describes the structure and outcomes of the course Creative Problem Solving (CPS) using data analysis from nine different offerings of the course. It then deepens in the methodology of the course by describing its challenge-based structure which utilizes generative learning based on the ‘do something different’ (DSD) approach. In order to design unique and pertinent solutions, students are encouraged to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. TTCT is used to measure their creative thinking skills at the beginning and end of the course. Detailed results of data analysis suggest that the creative abilities of students are significantly increased by taking Creative Problem Solving (CPS). And, as stated by Schön (1983), the authors agree on the need and desirability of highly developed creative skills to solve complex problems among the entrant workforce for industries both inside and outside design. This paper is relevant for the track as it addresses key questions such as: Why have design methods been adopted in higher education? And how have these methods been applied and adapted? Furthermore, it explores the context where creativity takes place, and about what is considered creative depending on students’ own cultural, habitual, and normal patterns of behavior.

Farzaneh Eftekhari, Mohammad Jahanbakht, and Farnoosh Sharbafi's paper, titled "Assessment of Ideation Effectiveness in Design Thinking: The Impact of Morphological Analysis in the Process of Creative Problem Solving", addresses the question: How can design help teachers and communities formulate solutions to problems? presented by the track. It evaluates the effectiveness of creative problem solving (CPS), recognized as a critical soft skill for students. The authors developed a study to determine the effectiveness of the ideation phase in a design thinking process applied by junior design students. They applied the MA (morphological analysis) method to observe students' ideation processes and their creative thinking by using four measures of novelty, quality, quantity, and variety, using quantitative and qualitative methods. The study suggests the use of the morphological analysis (MA) method to promote novelty in the ideation process and supports the positive impact of MA method in CPS process. The authors suggest using the measures mentioned before to assess other phases of the creative problem-solving methods in design thinking courses, as a way to inform educators about students' creativity performance. The paper contributes to the discussion of the conference's main topic (i.e., challenges in design education), but also to the specific theme track "Design Thinking to Improve Creative Problem-solving,". Additionally, the paper makes a significant contribution to design educators and educational researchers interested in studying the ways in which design thinking-based learning enables students to integrate knowledge from different areas through problem-solving, promoting an active and decisive mindset (Goldman & Kabayadondo, 2017).

In their article: **"Study on the Implementation of the Innovative Enterprise Product Design Model for Industrial Design Students"**, Shuo-Fang Liu, Jui-Feng Chang, and Chang-Tzuoh Wu, sustain that industrial design education often prompts students to focus on creativity and user needs, and lacks knowledge and concepts in marketing and sales. The authors propose the Innovative Enterprise Product Design Model for Industrial Design Students, as a method to guide students to address both consumers and the enterprise during their design processes. Students worked on applying this model in a specific design project through an eleven-week course. Content included the theoretical knowledge and application methods of the model. The products were assessed by the students themselves, groups of experts and the professors, showing an overall positive result after the model implementation. Findings raise relevant issues in design education from a robust methodological approach (i.e., the disconnect between some design curricula and current industry needs and practices). These include the need to emphasize teamwork, interdisciplinary communication and coordination abilities, as well as foster cooperation between design students and the industry (Yenilmez & Bağıllı, 2020). Students self-reported that they performed well and improved their innovation ability, product strategy formulation, and design maturity after using the model. Experts agreed on the quality of the design achievements, which altogether prove the feasibility of this design model.

In **"A New Design Thinking Model Based on Bloom's Taxonomy"** authors Fan Wu, Yang Cheng Lin, and Peng Lu explain that although there are many design thinking models around the world, they ignore the product's inherent characteristics and users' demands. This paper proposes a step-by-step design thinking model based on Bloom's taxonomy to assist with the use of Design Thinking Models in product design education. The paper provides an interesting, novel approach to integrating design thinking into product design education by taking a quantitative statistical approach to defining product characteristics. The paper combines numerous product engineering approaches to improve the implementation of design thinking by focusing on Bloom's taxonomy as an overall structure to achieve learning outcomes. The authors conclude that the proposed DTM can help students to carry out design activities step by step to obtain an accurate functional system, reasonable structural configuration, and therefore design the best solution that meets the real demands of users. The authors affirm that the model enhances the possibility of transforming conceptual design into commodities.

Design-based teaching and learning workshops

The two workshops present design-based models developed in different contexts to teach children and young people to identify and solve problems coming from their communities. They include visual elements, like flow charts and pictograms, and keywords that help participants to remember the process. FIDS for Kids methodology by Design for Change (DFC) allows educators to bring their students into the design mindset with a simple and agile method composed of four stages: Feel, Imagine, Do, and Share (Design for Change, 2017). While the Compass created by The Index Project® is a problem-solving tool that uses criteria as form, impact, and context to evaluate each process stage: prepare, perceive, prototype, and produce (Stenlev & Boegeskov, 2016). These models seem to be powerful didactic resources transferable to the field of education, but it is worth emphasizing that they are not formulas or recipes: they indicate certain milestones that occur during the design process and not a path to follow in a strictly linear way (Bravo, 2016; Bravo & Bohemia, 2019).

Natalia Allende and Ruthie Sobel Luttenberg's workshop entitled **"FIDS for Kids: Empowering Children**

through Design: A workshop on Design for Change's take on design thinking in education" is designed as a theoretical-practical tool for educators and parents to understand how to implement the DFC method into the classroom and beyond. Chosen by the United Nations as one of the ten initiatives around the world that will allow humanity to reach the global development goals, Design for Change offers a simple, flexible, practical, and meaningful tool inspired by design thinking in the classroom setting with children of any age from 7 to 18. The presenters deliver attendees a theoretical approach as well as a hands-on experience of this tool. The workshop **"How to Design to Improve Life: The Compass, a problem-solving tool by The Index"**, facilitated by Catalina Cortés and Mariano Alesandro, aims to introduce the Compass as a flexible frame of action to organize, structure, and manage problem-solving processes. During the session, the instructors describe the four phases through visual material and discussions, revise a series of cases to assess coherence for sustainability, and disseminate the Compass as a frame of action to manage problem-solving processes. The difference between this method and other design thinking models is its focus on maintaining coherence between form, impact, and context in every phase of the design process to evaluate solutions holistically and sustainably to improve people's lives. In this way, the aspects of the development of a design solution are covered such as function, potential, level of innovation, propagation, and economic, environmental, and social sustainability of the proposed design.

Final remarks

Today, new design domains are emerging. The fields of service design, experience design, food design, information design, or even biomaterial design did not exist as specifically defined domains decades ago. Beyond specific design themes, the success of applying design as a general set of attitudes and approaches to other domains has led to a permanent extension of the design domain.

There is no doubt that design provokes enthusiasm in school settings, but this enthusiasm opens questions such as:

- To what extent are the expectations of its application in the educational context fulfilled?
- What core design competencies should be introduced in general education, and how might they be mastered and evaluated?
- When and how should these competencies be taught?
- Who should be responsible for introducing these competencies?

Cortés, Adlerstein & Bravo (2020) suggest that models of design thinking available for teachers do not necessarily incorporate tacit pedagogical knowledge or unexpected decisions that unfold when teachers design and deliver learning experiences. Further understanding of teachers' design thinking black box would also contribute to reconceptualizing the available design thinking models for teachers.

At the higher education level, the presented articles show an ongoing enthusiasm for incorporating design-based educational strategies in the classroom, for continuing improving educational practices within design programs, and for making a positive impact on society at large through design-based education. However, the scale and scope of the initiatives presented in these articles and most of the interventions described in the literature remain very modest. Most of the reported interventions happen at the project or classroom levels and have a short duration, thus, impacting a limited number of students for a short period of time.

The current context shaped by the Covid-19 pandemic has abruptly modified pedagogical practices at a global level (Hodges et al., 2020). Design education has also been part of this phenomenon forcing educators to face the challenge of having to become distance design educators and migrate from face-to-face to virtual formats almost instantaneously. There is no doubt that the future of higher education will be hybrid, an education that will combine face-to-face with synchronous and asynchronous virtual interactions at the same time. What are the main competencies needed by future designers that can be acquired through online design education? What is the potential for online design education to support fundamental design skills?

For more than 40 years, design-based interventions in K-12 and higher education have been reported with success and enthusiasm by researchers, educators, and designers (Davis et al., 1997). However, in order to share the benefits of design approaches to learning with a more significant number of people, it seems necessary that future studies and interventions have a larger scope, a longer time frame, more substantial resources, and even more ambitious goals. We welcome all the initiatives presented for our Track and look forward to being amazed by the future contributions submitted to the Learn X Design Conference in 2023.

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End Users in Students' Participatory Design Process

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This exploratory case study aims to shed light on how end users were considered in students' design processes and final design products. A three-month participatory design project for students (ages 14–15) was created with the following brief: *“co-design and make an e-textile product for kindergarteners according to their wishes and needs”*. We analysed 72 transcribed end-users-related design episodes and the final products from two student teams. The findings indicate that students' end-users-related design discussions concerned various functional, technical, and visual/aesthetic features, as well as aspects beyond functional, such as students' memories and experiences. Additionally, many concrete and abstract features and solutions of the final products were traced back to end users. This study suggests new possibilities for engaging students in empathic and reflective (digital) design and making, targeting design-literate citizens in the 21st century.

Keywords: participatory design, design thinking, empathy, maker education, 21st-century skills

Introduction

Power structures in design have changed toward more participatory and collaborative design practices, and people are included in design as partners (Sanders & Stappers, 2008). To fully participate in society, all people should learn about design and develop (digital) design literacy skills (Nielsen & Braenne, 2013; Smith, Iversen & Hjorth, 2015). Design-based teaching and learning can support the learning of 21st-century skills, such as empathy, creativity, communication, and collaboration (Carroll et al., 2010; Noel & Liu, 2017; Tellez & Gonzalez-Tobon, 2019).

Smith et al. (2015) suggested design thinking as a framework for engaging students in the design of digital technology, and the possibilities of maker education and maker-centered learning have been explored in terms of educating future citizens with capabilities and confidence for actively participating, understanding, and developing a “digitalized world” (Clapp, 2016; Halverson & Peppler, 2018; Konopasky & Sheridan, 2020). Here, schools play an important role, and formal education should democratically offer these new skills and possibilities to children and adolescents (Blikstein, 2013). However, Dindler, Smith and Iversen (2020) argued that issues such as how technology is meaningfully constructed for specific people in a concrete situation, undertaking design research, and developing empathy for users are seldom found in the lower-level school curriculums. How do we then engage students in maker-centered learning, building creative skills, socio-emotional skills, and technical capacity, and enable them to learn (digital) design literacy and other 21st century skills?

Design thinking and its methods and techniques can support student's active engagement in solving wicked, ill-defined problems by trial and error and based on their insight and past experiences (Cross, 2011; Goldman & Kabayadondo, 2016). Design thinking is defined and described in various ways by many researchers and practitioners, especially in design, engineering, and business. Examples include widely known IDEO's Design Thinking process, Stanford Design Thinking Diagram, or Design Council's Double Diamond process. Participatory design (PD) “ideology” offers new ways and possibilities for applying design thinking in the fields of learning sciences to develop and transform its practices (DiSalvo & DiSalvo, 2014). Derr (2015) suggested that collaboration with the community is an important aspect of the PD approach, and it can play an important role in school-based PD projects to enhance design skills and empathic development. This exploratory case



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study aims to shed light on how end users were considered in students' design discussions and final products. By relying on van Rijn, Sleeswijk Visser, Stappers and Özakar's (2011) notion that end-user-related discussion can indicate design empathy, we aim to reach a better understanding of students' design discussions. In the present study, we asked: 1. What kind of end-user-related design discussions did the students have? 2. In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?

Empathy toward the end users in the design

End users' needs and perspectives have to be taken into consideration beyond the functional (e.g., emotional, cultural, or social needs), to design personal and meaningful solutions (products, services, and experiences) for them. 21st century "soft skills" (e.g., empathy, creativity, communication, collaboration) are the core future design skills, as they enable this connection with people and communities (Clapp, 2016; Noel & Liub, 2017; Tellez F. & Gonzalez-Tobon, 2019; Woodcock, McDonagh & Osmond 2018).

The original aim of the empathic design was to understand and make sense of the human experience and to purposely use the knowledge gained for developing successful products. However, in the past decades, users have been more actively involved through co-design and PD methods for building possible alternative futures (Koskinen, Battarbee & Mattelmäki 2003; Tellez F. & Gonzalez-Tobon, 2019).

Even though empathy is seen as an essential part of design, the field lacks a fundamental understanding of what design empathy is: how it functions in the design process and how it can be evolved, supported, and accomplished. Earlier research has focused mainly on developing and utilizing different methods and techniques rather than the more holistic empathic growth of a human (Hess & Fila, 2016; Mattelmäki, Vaajakallio & Koskinen, 2014; Smeenk, Sturm & Eggen 2019).

Smeenk et al. (2019) note that empathy in social-psychological literature is usually divided into cognitive processes and affective experiences, and the ability to attune to or distinguish between self and other. Kouprie and Sleeswijk Visser (2009) created the framework for empathy in design, which integrates these factors, and they emphasized the need for a balance between users' ideas and visions as well as designers' personal insights and experiences. Smeenk, Tomico & van Turnhout (2016) stated that acknowledging different perspectives is valuable in design. Similarly, Hess and Fila (2016) found that designers' reflections and first-hand experiences were an important part of the empathic design process.

Research settings

This qualitative case study was organized at a public lower secondary school in Helsinki as part of an elective eighth-grade craft course. Ten female participants (aged 14–15 years), who had prior experience with textile crafts but no prior experience of PD, design thinking models, e-textiles, or collaboration with kindergarteners, were divided into three teams. Two kindergarten teachers and 16 kindergarteners (aged 6–7 years) participated in the project (later the teachers, as well as the kindergarteners, are referred to as the end users). As the kindergarten was located next to the school, some participants had attended it. The project structure was designed mostly by the researcher/craft teacher/designer (later the researcher), who made the overall planning based on her prior knowledge and experiences of design and craft education. However, the plans were collaboratively discussed and revised on a weekly basis with the responsible craft teacher. The overall idea for the project was formed in collaboration with the kindergarten teacher.

The design brief for the project was to "co-design and make an e-textile product for the kindergarteners according to their wishes and needs." The task emphasized collaboration between team members, taking other peoples' ideas, feelings, and needs into account, and thinking creatively about how technology could be used in the products. Additionally, the students left the school building to take on the role of "participatory designers" in front of the kindergarteners. They connected with the community and considered their roles in it.

The project was carried out over three months in the spring of 2019. The class met 12 times in weekly 90-minute sessions; the last three sessions were dedicated to student presentations and post-questionnaires (see Table 1). The teams documented their processes in the digital SeeSaw portfolio. Both the teacher's and researcher's roles in the process were active yet more facilitative than authoritative. The students were supported in finding their own paths to contribute to the design process.

Table 1. The design process steps, and activities (*not included in the analysis)

Sessions	Design process steps	Activities
1	Discover & empathize	Memories and reflections in a post-it note. Filling up the pre-questionnaires.
2	Discover & define	Visiting kindergarten. Observations of the space. Direct interaction with end users. Collecting needs and wishes.
3	Define & develop	Forming the small groups (ice breaker). "How might we..." questions. Ideation in small groups. Defining the challenge.
4	Develop & deliver	Ideation in small groups. Making the fast mock-ups. End users visiting for presentation and feedback. Collecting feedback.
5	Develop & deliver	Developing the concepts ready according to the end user feedback.
6	Manufacture	Manufacturing the products.
7*	Manufacture	Open day: parents visit. Manufacturing the products.
8	Manufacture	Manufacturing the products.
9	Manufacture	Finalizing the project and poster.
10*	Deliver & present	Delivering the outcomes. Presentations for the end users.
11*	Share	Sharing for a wider audience at the UH Invention Fair.
12	Reflect	Filling up the post-questionnaires. Reflecting the overall process.

The project followed the Double Diamond design model (British Design Council, 2005) and started with empathizing. Students made empathy maps, visited the kindergarten for needs observations, and interacted with the end users. Based on those observations, needs, wishes and discussions with the end users, the researcher put together different HMW questions, and students brainstormed solutions for the design challenges and voted for the favorite concept to work with. Then, concepts were developed (Figure 1), and rapidly constructed mock-ups were presented to the end users. Concept designs were developed based on the end user feedback in Session 4, and the manufacturing phase started. In Session 7, there was an open day (extra school day on Saturday), where parents were invited to visit; some of them even helped students with the making phase. Lastly, the functional needs-based design products "Season Tree" and "Strength Crow" were brought to the enthusiastic preschoolers, and a toast was made to celebrate the big accomplishment. Later, the students and the teacher presented the project (Session 11), the city-center "Invention Fair," organized by the research team from the University of Helsinki.



Figure 1. Student designers from Team 1 working with the design challenge.

Data and analysis

In this study, we focused on analyzing the processes of two student teams (*names pseudonyms*). Team 1 (Emmi, Sofia, and Sara) designed a "Season Tree" to help preschoolers learn about the different seasons. Team 2 (Iina, Senja, and Rosa) designed and manufactured a soft toy "Strength Crow," a popular figure in

Finnish early childhood education for supporting positive pedagogy and strength-based education (Vuorinen & Uusitalo, 2015). It also functions as a noise level meter. The two teams were chosen according to students' willingness to participate in the study.

Research permissions were obtained from all participating students, and versatile data were collected during the project. The primary data consisted of approximately 18 hours of video recording, photos of the sketches, mock-ups, observation and ideation notes, and final design products. The secondary data consisted of the researcher's field notes, students' pre-questionnaires and post-questionnaires, and other pedagogical material. Some sessions (7,10,11) were left out of the analysis because they did not offer any new design aspects to the design process. In some of Team 1's sessions, we had technical problems capturing students' voices as they actively moved around the classroom. Altogether, analyzed video data consisted of approximately 10 hours of video recording.

The qualitative data analysis was done in several cycles and levels, adapting the model proposed by Derry et al. (2010). The first phase consisted of making a rough content log of the whole video data to obtain an overall picture and reveal the main contents and various activities of the sessions in the design process. Then, we systematically identified all those episodes in which students' teams had discussions related to end users, e.g., the user environment, or possible future use of the design. We utilized MAXQDA software for qualitative data analysis, and the identified episodes ($n = 72$) were transcribed verbatim. By analyzing the students' team discussion relating to end users, we were able to reveal the kinds of motivations, concerns, experiences, and reflections the students' team exposed through their design process. The overall analytical process was accompanied by the writing of memos, which included, for example, definitions of categories, preliminary analytical notes, and questions of analysis. Whenever the transcriptions did not offer the full picture of the moment, we returned to the video data to strengthen the analysis.

In the second phase, we created a process table (similar to the flow chart; see Ash (2005) to support the analysis. To this end, we added versatile basic information (e.g., session, phase of project, data collected, assignments) next to end-user-related transcriptions. We also included photos of the sketches, mock-ups, notes, and design products to keep better track of the overall process.

To answer the first research question, we utilized data-driven analysis to identify the main functional and beyond functional aspects related to different kinds of end-user-related design discussions. Functional aspects consisted of functional features or solutions (how product functions or what it is meant for, e.g., what does it teach for children?), technical features or solutions (how the product can be produced, e.g., which material fit or what kind of digital functions can it have?), and visual and aesthetic features (what the product will look like, e.g., attractiveness and shape).

Beyond functional aspects included other-oriented and self-oriented categories. Students' other-oriented end user considerations were derived from end users (e.g., based on the observations) or their needs, wishes, and feedback (e.g., kindergarteners learn about seasons or end users preferred some color). Students' self-oriented experiences and knowledge included, for example, their own experiences from kindergarten, experiences of the topic at hand, or the kindergarten visit from Session 2 (e.g., how was it in kindergarten or during a previous experience of making).

Lastly, to answer "In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?", we focused the analysis on the photos of the sketches, mock-ups, and final design products and listed the main end-user-based features and solutions. Next, we went through the listed features and solutions next to the process table with all the transcriptions to reveal the process and connections between the needs, wishes, feedback, and the final product.

Findings

We analyzed what kind of end-user-related design discussion did the students had. Furthermore, we analyzed how the end users were acknowledged in the final design products. Next, we present the findings for our research questions.

RQ 1. What kind of end-user-related design discussions did the students have?

This first level of analysis revealed that students considered many functional, technical, and various visual/aesthetical aspects or solutions. Table 2 provides the frequencies of these main aspects of the episodes. Since we were not interested in the frequency of each functional aspect (e.g., how many times Velcro was mentioned in one episode), we present our findings from a wider perspective, relative to the episodes. It is important, however, to notice that these five categories were not exclusive, and most of the time, the students' discussions related to many categories within the same episode.

In both teams' processes, the most common end-user-related design episode was related to the functional and other-oriented aspects. In Team 1, 27 of 39 episodes dealt with functional aspects, and 32 with other-oriented aspects. Of all the analyzed episodes, Team 1 also dealt with technical (26/39) and visual (24/39) aspects of the proposed product more often than Team 2 (16/33). The findings suggest that other-oriented end-user-related considerations, as well as students' own self-oriented experiences, played an important role during the design process, even though Team 1 referred to experiences more often.

Table 2. Frequencies of the main aspects of the episodes.

<i>Team</i>	<i>Total number of episodes</i>	<i>Functional</i>			<i>Beyond functional</i>	
		<i>Functional</i>	<i>Technical</i>	<i>Visual /Aesthetic</i>	<i>Other-oriented</i>	<i>Self-oriented</i>
Team 1 Season Tree	39 episodes	27	26	24	32	21
Team 2 Strength Crow	33 episodes	23	16	18	25	12

The functional category included various considerations of the purpose of the product or the kinds of intended functions it might perform. Team 2 (Strength Crow) pondered, for example, whether the Strength Crow could play a sound when the noise in the class is too loud, thereby functioning as a noise warning system. Team 1 (Season tree) discussed how children could decorate the tree by themselves, and how snowflakes could represent the wintertime, and green leaves the summertime. Technical considerations related mostly to material choices, for example, whether Velcro should be used to attach the strength cards to the Strength Crow or whether real (wet) branches should be used on the Season Tree. Considerations of the water resistance of the programmable board, the strength of the material, or issues of coding were also included in technical considerations. The visual and aesthetic aspects were also actively considered by both teams. Team 1, for example, pondered whether the sketch of the Season Tree looked scary and how to make the tree more attractive with bright colors. Team 2 considered whether capital fonts were easier to read, or rainbow colors well liked.

The other-oriented category consists of notions derived from or concerning the end users or their situations, needs, wishes, or feedback. This category represents the clearest end-user-centric considerations during the design process, for example, statements recalling what the end users had expressed earlier. These needs and wishes were especially discussed during the ideation phase, where the students ideated different solutions, for example, by proposing a "dressing-up game" to motivate the children to dress up layers of cold weather clothing faster or to make dressing funnier. Later, the student teams considered what kind of feedback they could request from the end users, or how teams could include user wishes into the design of the artifact.

The self-oriented category consists of notions during which students brought up or memorized their own prior experiences in kindergarten, the kindergarten visit, or making. Team 2, for example, discussed what they played on the kindergarten field trips. They also referred to the experiences collected during the kindergarten visit and used personal emotions as part of the design. Earlier experiences of making were also in this category as if they were connected to making for the end users.

RQ 2. In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?

The second analysis concerned the way the end users (both preschoolers and their teachers) or their needs, wishes, and feedback were acknowledged in the final design products (Figure 2). We analyzed the photos of the sketches, mock-ups, and final design products, and the main features and solutions derived from the end users were listed (see Table 3, right column). Then, we compared those features next to the process table to reveal connections between the end users' stated needs/wishes/feedback and the final product. The findings show that many concrete or abstract features can be traced to the end users' needs, wishes, and feedback. Next, we explained in more detail the different end-user-derived features and solutions of both products. Both teams' solutions were developed to offer tangible, concrete products to support kindergarteners' learning. The main function of the Season Tree was to demonstrate different seasons in a more realistic and motivating way, as children could change the leaves, flowers, and snowflakes by themselves. The Strength Crow was developed for playing and supporting strength-based education and measuring the noise level. During the kindergarten visit, Team 2 noticed that the space was small and noisy, and it triggered the idea of utilizing the programmable e-textile board for this purpose.

Presentation and feedback sessions between eighth graders and end users were very concrete by nature. The main kindergartener feedback noticeable in the final products was the size of the Strength Crow and its bill, as

well as the larger size of the Season Tree compared to the sketches and mock-up version presented to end users. Further, the end user feedback offered some new ideas for the material and functional aspects, but the wishes were rather contradictory or were not included in the final design due to the very limited timeframe or other technical challenges.



Figure 2. Season Tree and Strength Crow: Products designed and manufactured by the students.

The end users were acknowledged in both final products in many ways (see Table 3). For example, when the students discussed how the strength cards should be attached to the Crow, they first considered the usability and safety issues between using pins or Velcro and then chose Velcro, thinking of the end users. This view was supported by end user feedback, as preschool teachers supported it. In the same vein, Team 2 considered the materials to be strong enough to prevent Crow from breaking in children's hands.

When selecting the font size, type, and color for the strength cards, students paid attention to the visibility. They pondered what type and size of the font the end users (kindergarteners) might be able to read or what type of font color the end users might like. Furthermore, visibility was also considered in terms of LED lights and programmable boards, and different color LED lights were considered suitable for the end users. All these points were visible in the final Crow.

The Season Tree team considered Velcro fastening an easy and safe way for end users to use, but also changing the batteries and hanging the tree on the wall was considered for better usability. Bright, colorful flowers and colorful LED lights were considered for a livelier and more attractive look for the Season Tree, which end users would appreciate. The form of the tree was developed to be a softer and nicer bushy tree, so the kindergarteners would not get scared of it. In general, the team was trying to make the tree look impressive and beautiful by making the Season Tree rather large (around 1 m high) and filling up the tree with flowers and leaves.

Table 3. End users and their needs, wishes, and feedback acknowledged in final products

Team	Needs and wishes stated by the end users Feedback from the end users*	End users acknowledged in the final products
Season Tree	• Tangible and more attractive season tree • To support learning about seasons • Size of the tree bigger than in mock-up version* • Not necessarily real branches*	• Educational function (support learning, recognizing the seasons) • Different kinds of flowers, leaves, raindrops, and snowflakes demonstrating the seasons • End users can decorate themselves • Bright colors for a more attractive look • Nice, friendly-looking, and soft bushy tree for end users (not scary) • Size of the tree fairly big, impressive • Appearance lively and attractive (e.g., led lights, a tree full of leaves) • Usability (e.g., battery change, Velcro binding, no real branches)
Strength Crow	• Tangible, concrete Strength Crow • To support strength-based education • Size of crow and its bill adjusted according to end users' feedback* • LED lights for eyes* • Velcro for binding*	• Educational function (support learning, recognizing the strengths) • Noise level meter (sound & light) • For playing • Chosen weekly strengths can be attached • Velcro binding (for safety & easier usability) • Visibility for the end users (e.g., fonts & colors) • Usability (e.g., change of battery, the strength of the material, can stand on its own on a table) • Appearance-friendly and colorful (e.g., LED lights)

Discussion

This exploratory case study aimed to shed light on how the end users were considered in students' design discussions and final products. These eighth graders were able to practice participatory and empathic design by acknowledging end users in multiple concrete and more abstract ways. It was visible in various end-user-related discussions and considerations, which materialized in the final products.

Following Woodcock et al. (2018), we acknowledge the need to consider features beyond functional to design personal and meaningful products for people; thus, we based our analysis on various types of user-related design process data, and eight graders' memories and experiences. Our findings show that beyond functional features can bring us closer to design empathy, and end-user-related topics were discussed repeatedly during students' design process.

As earlier research suggests (van Rijn et al., 2011), direct contact and interaction with real end users have proven to be an effective way to increase students' motivation and engagement for the students. We surmise that, with adolescents or younger children, direct contact and students' previous own experience from the context were crucial for motivational reasons, as well as for making the whole design thinking process more concrete and being able to apply different perspectives in design. Everyone had an experience of kindergarten and its practices (as kindergarten is obligatory for children in Finland), and that was the important connector between the students and the end users.

The motivation and engagement grew especially in contact with end users, and data from students' post-questionnaires supported this view. For students, collaboration, interaction, and hearing kindergarteners' opinions about the products were inspiring. Moreover, some students mentioned that recalling memories of their preschool times at the beginning of the process helped in thinking about what preschoolers are like and which things are important to them.

The eighth graders' ideated concepts were to be manufactured by the students; thus, during the process, they referred to their previous experiences with sewing or coding. This might have affected the design process, as certain skill or material constraints were there. However, students also drew inspiration and knowledge from their experiences, which is considered beneficial in the process of learning.

Limitations and reflections

This study was a small case study on applying empathic design in the eighth grade PD project with real end users. The sample size was small but suitable for this kind of pilot project. Due to the gendered division in Finnish craft classes, all students participating in the project were girls. To increase trustworthiness, we offered the overall picture of the aims, goals, and process implementation to the full extent and described and justified the data collection methods and analysis as precisely as possible.

A small student-teacher ratio enabled time for instruction when two adults were all the time supporting three teams. It was necessary for the narrow time restrictions given to the project, and we noticed the small pressure of the students in trying to complete the products. Due to the small size and situated nature of this study, the findings cannot be generalized, but these findings pave the way for new studies of empathic PD with a wider group of attendees in different schools and grades. Students gave permission for data collection; however, as this project was part of their formal education, the project itself was not voluntary for students. This and the fact that the project class was at 8 AM every Friday and the students were teenaged could have affected some students' active participation.

The researcher being familiar with the setting and school and being present and co-designing all sessions with the teacher have supported the analysis. Additionally, this familiarity led to honesty, trust, and openness between the teacher, researcher, and students and increased the positive and open atmosphere for sharing experiences and risk taking.

Even though the PD process was a dialogic process between teachers and students and other stakeholders, this study focused mostly on students' verbal design discussions. However, it is good to keep in mind that in many moments, the researcher and teacher might have been starting the end user talk by asking a question, proposing an idea, or giving a design task (such as HMW questions). We have not separated these moments in this analysis. Further, end users' needs and wishes mostly came from the preschool teacher, not the six-year-old children themselves. We focused strictly on what the students said; therefore, the idea and the design concept were considered their own. Nevertheless, teachers' role in this kind of open-ended process is significant.

Conclusion

The findings of this small-scale study broaden the knowledge of how lower secondary level students can practice participatory design and include end users in their design processes. These small local PD projects can offer new possibilities and directions in engaging students in critical and sustainable design and making in formal schooling, targeting active and design-literate citizens of the 21st century. However, this novel field requires further studies on educational contexts other than higher education, which currently has the best research coverage.

Future studies could address, how these community-based participatory and empathic practices can be supported in formal education, e.g., how teachers can scaffold and balance the process with structure and freedom and offer certain tasks to feed implicit learning goals (such as different 21st-century skills) into the process.

By scaling up these local design projects first to a greater number of schools at different levels and contextual places and areas of living, developing the practices and teaching materials together with the teachers and school leaders, we can build new frameworks and ways of working with participatory design in educational settings and activate young students to take part in community development.

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Integrating Design Thinking into STEAM Education

The Design of STEAM Education Platform and Course Based on Creativity Elements

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The fast development of artificial intelligence in modern society facilitates the needs of creative education. Design thinking, an innovative thinking frame, is benefit to cultivate children's creativity. However, little research has clearly explained how to use design thinking to improve creativity. Therefore, this study aimed at integrating creativity and design thinking into STEAM education (Science, Technology, Engineering, Art and Mathematics), and thereby cultivate students' problem solving and creative ability. Firstly, 151 school-age children participated in the study and finished the creativity tests. Second, dimensions of creativity (e.g., adventure, curiosity, and flexibility) that were significantly related to academic performance were abstracted as core design elements of the education platform. Third, the STEAM education platform model and curriculum design model were established based on the core design elements abstracted and design thinking. These models contribute to scientific ways of designing a STEAM education curriculum and platform aiming at improving school-age children's ability of creativity. With the STEAM education platform, students' practical and problem-solving ability were expected to be improved.

Keywords: design thinking; STEAM education; creativity; education platform; design research

Introduction

The rapid development of Internet technology prompts us live in the world of artificial intelligence, with increasing demand of high-level creative talent. Therefore, creativity education is required to cultivate creative talent. STEAM educational idea, formed by the interdisciplinary integration of Science, Technology, Engineering, Art and Mathematics, focuses on cultivating students' innovative consciousness and ability (Chang & Zhang, 2018). Oriented towards developing students' problem-solving abilities, STEAM education is beneficial for students' creative problem-solving ability. STEAM teaching idea has been applied in the curriculum of primary and secondary schools.

With the development of 5G technology and the spread of global Covid-19 epidemic, online education is steadily recognized by students and parents. However, little research about the design of STEAM online platform exists currently. This article aims to combine the creativity with design thinking to form a design model in the interactive design of education platforms. The research not only helps the spread of STEAM innovative education, but also exercises students' problem-solving skills while providing an evaluation method for curriculum as well.

In the following sections, we start by discussing the related conceptions of creativity and design thinking in general, followed by discussion of applying creativity dimensions in integrating design thinking into STEAM education, as a model of thinking, through creativity elements not only build an education platform model, but also construct a curriculum design model.



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Literature review

Creativity Definition

In the 1950s, psychologist Guilford firstly proposed the concept of creativity. For a narrow definition, Creativity represents the most prominent ability of a creative person, because whether a person can produce creativity depends on his own motivation and temperament characteristics, creativity belongs to a creative personality with personal characteristics from personal perspective (Guilford, 1950). The definition of creativity is not only limited to creative personality. Creative thinking also belongs to creativity research. As a cognitive activity, creative thinking is responsible for producing innovative and practical products (John & Zhou, 1993). Both the creative personality and creative thinking that represent creativity can be measured by behavioral questionnaires in the psychology field. Creativity training is based on creative learning. Academic performance is often used as an important indicator to measure the effect of students' learning (Wei, 2014). Recent research applied theories of creativity in education design, and it analyzed uses of creativity theory in lessons and projects (Kaplan, 2019). Another article pointed out that more theorists no more focus on dynamic process of creativity but are interested elements of creativity (Mehta & Dahl, 2019).

The Relationship Between Creativity and Academic Performance

Affected by the trend that China encourages the cultivation of creativity, the relationship between creativity and study also arose attention from some scholars. Some studies took high school students as the test group. These results show the significant positive correlation between learning self-efficacy and academic performance. There is significant difference in the creativity adventure and imagination among students with different self-efficacy. It has been found that adolescents' creativity adventure, curiosity and imagination levels are significantly correlated with academic performance (Yang et al., 2013). Although these studies were tested in different age groups, they all proved that the dimension of creativity is significantly related to academic performance and learning efficacy. Some researchers used elementary school students as main group and found a significant positive correlation between learning self-efficacy and academic performance (Song, 2019). Some other research also showed that learning efficacy can significantly predict academic performance (Wen, 2016). The above research suggests that a close relationship between learning self-efficacy and academic performance. Hence, the research can be used as a relevant indicator of learning to measure the relationship between creativity and learning. There is a view that intelligence has a greater impact on academic performance than creativity (Wu, 1988), so intelligence should be used as a controlling factor. The core ideology of STEAM education is to cultivate creativity competence, STEAM education also has impact on students' academic performance.

Creativity and Design Thinking

The researcher pointed out that cultivating creative thinking is considered to be one of the core abilities of future-focused learning and as creativity also includes creative thinking, Conversational Task Models and Visual Representation Task Models were proposed for cultivating creative thinking. Methods of incorporating creativity into learning assessment also was discussed (Rosen et al., 2020). Recently, researcher found that design thinking can promote creativity. The experiment conducted a 3-day training course called Design For Change for 255 middle school students, and conducted divergent thinking tasks and self-confidence tests before and after the training. The final results indicate that Design thinking has significantly improved the fluency and descriptiveness of creativity, and also enhanced the self-confidence of students, but the flexibility and originality of creativity were on average lower than those of the control group (Rao et al., 2021). The above research shows that employing the quantitative method to study design thinking how to applied in education has become a new trend and direction. In fact, Liedtka pointed out that design thinking as a new social technology, many researchers had ignored the potential of design thinking can improve creativity (Liedtka, 2018).

STEAM Education and Design Thinking Applied to Creativity Training

Both STEAM education and design thinking are models of interdisciplinary cooperation and problem-solving, which can promote economic innovation and facilitate the cultivation of skills and entrepreneurship in the 21st century (Jagodzinski, 2012; Kalin, 2019). STEAM education first emerged in the United States. It was originally produced to meet students' needs of scientific interest training and scientific skills learning. With years of development, STEAM education has become more popular among K-12 schools in the United States. Scholars proposed the diversified education model, believing that the purpose of STEAM education is to integrate

common skills. These common skills include learning empathy and interdisciplinary learning, the skills that can propose creative solutions to problems, and encourage students to do a new attempt (Perignat & Katz, 2019). Chinese researchers divided STEAM education into project completion-oriented learning forms and problem-solving-oriented learning forms by the STEAM education learning form (Yang et al., 2020). In recent years, the content of STEAM courses is apt to programming. Other countries integrate art design and programming into STEAM education. For example, elementary school students accomplish logo design by applying graphic programming while integrating multidisciplinary content during the whole process (Park, 2016).

The Design Thinking model usually includes five processes: empathy, problem definition, conception, prototyping, and testing (Ambrose & Harris, 2010). Based on project-based learning, Design thinking focuses on innovating or solving problems (Henriksen, 2017). STEAM education and Design Thinking may expand the boundary of subject area and create a hybrid way to understand and represent knowledge. STEAM and design thinking's most argument is that they have cultivated the vital creativity, financial ability, innovation and entrepreneurial spirit in the 21st century (Allina, 2018; Costantino, 2018). The combination of design thinking and STEAM education already has practical application. A teacher from Arizona State University instructed her normal graduate students and design an interdisciplinary STEAM project. She explained how design thinking guides pedagogical STEAM course design and integrate it into the STEAM course's various elements to design more interdisciplinary and innovative courses (Henriksen, 2017). The design thinking model is appropriate for STEAM courses design refer to the design thinking process at present.

Above all, creativity ability has a significant relationship with students' academic performance, and STEAM education plays an essential role in improving creativity ability. Therefore, many people use STEAM courses to improve people's innovation ability and comprehensively improve students' learning effect. However, creative ability is complicated. Previous studies have not clearly stated which dimensions have effectively improved the overall performance of students. Therefore, the past innovative curriculum platforms lacked pertinence. The present study focuses on those dimensions of innovation that enhance learning, and then design the platform based on these extracted factors.

The previous research has some problems as follow:

- Failed to propose indicators that can estimate the effect of innovation education combine with design thinking.
- Lack of mature and Innovative methodology to apply design thinking into STEAM education well, rare design practice of integrating design thinking into digital education platforms.

To tackle these voids, this paper adopts quantitative analysis methods to build design model for exploring the better application of design thinking into STEAM education. In the research, creativity is proposed as a quantitative indicator to measure the effect of STEAM education platform, and creativity elements as well as are applied in construction to generate two design models. These models propose good strategies and innovative ideas for the application of design thinking in the platform of STEAM education.

Method

This research used behavior questionnaires to obtain the elements of creativity related to academic achievements and combined them with design thinking to construct a complete interaction design model of the STEAM education platform. There is the whole methodology flow is shown in Figure 1.

Participants

The sample of the behavior questionnaire was 151 students aged between 10 and 12 from a school in Shenzhen, China, among whom 93 were boys and 58 were girls.

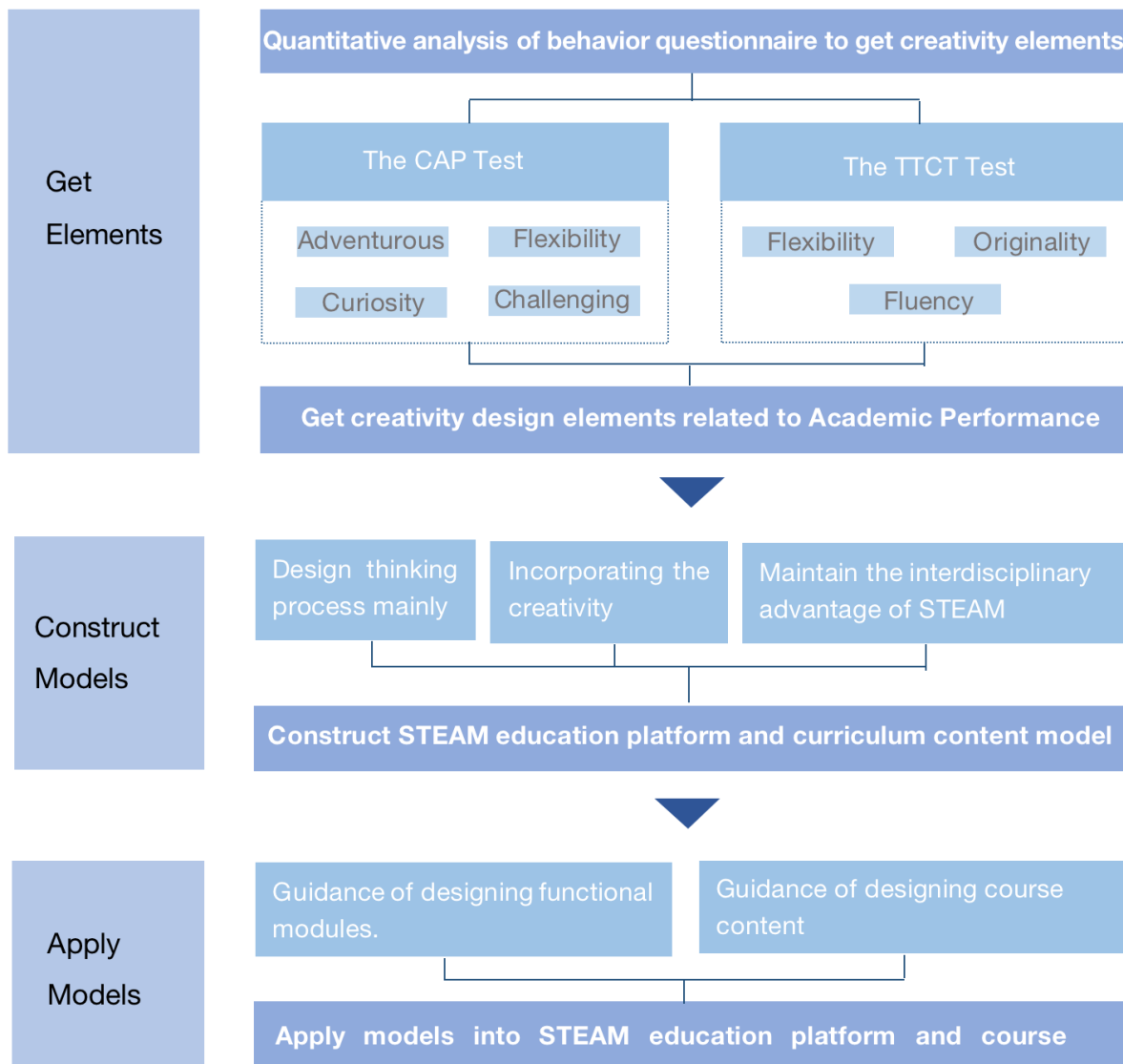


Figure 1. Methodology Flow

Measures

Raven's Standard Progressive Matrices (R. SPM) was accomplished by Raven in 1938. The Chinese city edition of the matrices, revised by Houcan Zhang, was one of the evaluation tools used in this research to meet the need of the group test for measuring intelligence (Zhang, 1989). The R.SPM has 60 multiple choices, divided into five groups from A to E, which means 12 questions for each group. The difficulty of each group increases by groups' labels. Participants who answer correctly will get the corresponding score. Next, the raw score of participants converts to a standardized score according to participants' age. The standardized score considers an intelligence score, which acts as the control variable in statistical analysis.

The Creativity assessment packet (CAP) (Williams, 1980) used for measuring creativity personality tendency was compiled by American psychologist Williams. The Mandarin edition of the CAP was employed for the current study. This test is unmistakable for its standard scoring rules, and it is suitable for group test which aged from 10 to 18. Williams Creativity Propensity Inventory contains 50 questions corresponding to 4 dimensions, including imagination, curiosity, risk-taking, and complexity. The Williams test scoring rules utilize 3-point scoring (Liu et al., 2011) and finally get the total score of creative personality and the score of each dimension, representing the level of creativity personality. A higher score represents higher creativity level. Academic self-efficacy scale (ASRS) established by Liang and Deng (2018) can be used to measure students' learning self-efficiency, have good reliability and validity test, and be widely used in China to measure self-efficiency in learning (Liang & Deng, 2018). The questionnaire consists of 22 questions for two dimensions: self-efficacy dimension of learning ability and learning behavior self-efficacy. Each dimension takes 11

questions. The questionnaire uses 5-point scoring, and the total score of 22 questions becomes the final score of the test. A higher final score represents higher academic self-efficacy, while a lower score means academic self-efficacy is relatively low.

Torrance Creative Thinking Test (TTCT) was improved by Torrance based on Guilford's divergent thinking test and applies to many people, including the range in age from kindergarten to graduate school (Kim, 2010). The test should respond to the given language. The test offers the result from fluency, originality, and flexibility. TTCT is divided into language test and graph test, corresponding to linguistic creativity and graphic creativity. In this study, product improvement questionnaire A in language test was selected for the test. The scoring criteria for language task would be used grading and obtain the score for three dimensions of creativity and the total score.

Procedure

The test acquired permission from the school authority, students' parents and teachers, them all had signed the informed consent. Students filled in the personal document and finished the Raven's Standard Progressive Matrices in front of computer, which took about 40 minutes. Then they continued completed the Williams Creativity Propensity Inventory, Academic self-efficacy scale, and Torrance Creative Thinking Test, submitted the questionnaire immediately after completion. supervisors need to confirm the submission is successful. Computers automatically measured the information from the questionnaire and supervisors checked the relative information to ensure the completeness of participants' information.

Scoring

The behavior questionnaires received 151 pieces, and one researcher processed all the questionnaires' data with standardized coding to avoid errors caused by the tester's inconsistent coding. The questionnaire requiring subjective rating was scored jointly by two researchers, and then calculated the average score of two researchers as the final total score of the subjects. The co-completion of the grade had higher reliability than individual grading. The reliability of this research is between 0.574 to 0.774.

All the tests during this research were completed by online questionnaire. Participants completed the questionnaire in the computer classroom, and researchers downloaded the original data from the online questionnaire website. In the beginning, researchers made the data reduction through Excel and calculated the total score by procession the data into SPSS.19 software. Based on the research problem of the relationship between creativity and study, correlation analysis was conducted first and then proceeded regression analysis and extracted the design elements related to creativity.

Result

The Facilitating Effect of Different Creativity Dimensions on Academic Performance

The creativity in this paper included seven dimensions: curiosity, risk-taking, imagination, challenging, fluency, flexibility and originality belongs to creative thinking. To explore the relationship between different dimensions of creativity learning self-efficacy, and academic achievements, study put these variables in SPSS software to do correlation analysis.

Table 1 provided the score of risk-taking, and curiosity in creative personality was significantly related to learning self-efficacy and academic achievement, while the score of flexibility in creative thinking was notably related to learning self-efficacy and academic achievements.

In order to explore how does the degree of creativity dimension affects learning efficacy and academic achievements, risk-taking, curiosity and flexibility were taken as independent variables, while learning self-efficacy was taken as dependent variables, and the students' age, gender and intelligence scores were taken as control variables. The software SPSS.19 was used for linear multiple regression analysis.

Under the condition of controlling variables such as age, gender, intelligence etc., the risk-taking and curiosity of creativity still present positively predict learning self-efficacy. The result Table 2 shown the regression analysis result indicated that higher proportion of adventurous and curious in the creative personality led to stronger perceived academic self-efficiency. What is more, the learning efficacy also influenced the study.

Table 1. Correlation Analysis Result of Creativity Dimensions

Creative variables	M	SD	Learning self-efficacy	Academic achievements
Total score of creative personality	112.774	12.274	0.599**	0.175*
Imagination	27.815	4.240	0.424**	0.077
Risk-taking	24.205	3.297	0.537**	0.169*
Curiosity	33.007	4.265	0.553**	0.181*
Complexity	27.748	3.114	0.456**	0.156
Total score of creative thinking	8.298	4.541	0.197*	0.244**
Fluency	4.447	2.742	0.151	0.193*
Flexibility	3.090	1.626	0.233**	0.274*
Originality	0.765	0.780	0.131	0.169*

Note. N=151, *p < .05(two-tailed) ; **p < .01(two-tailed) ; *** p < .001(two-tailed)

According to the features of risk-taking dimension in creativity, the result indicated that people who have strong creative risk-taking traits are willing to face to failures or criticisms, attempt difficult thing sand believe in themselves. By doing so they would have a sense of achievement. This may affect their sense of self-efficacy. In addition, they believe in their ability. Even in the face of learning difficulties, tasks can be completed by them. This is just in line with the self-efficacy dimension in learning ability.

Table 2. Regression Analysis Result of Creativity Level in Predicting Learning Self-efficacy

Independent variables	R ²	△ R ²	B	SE	Beta	F	P
Age	0.410	0.386	-6.509	2.845	-0.149	-2.288	0.024*
Gender			-1.620	2.007	-0.055	-0.807	0.421
Intelligence			0.050	0.037	0.089	1.338	0.183
Curiosity			1.153	0.294	0.333	3.917	0.000** *
Risk-taking			1.382	0.372	0.308	3.710	0.000**
Flexibility			0.720	0.633	0.079	1.138	0.257

Note. N=151, *p < .05(two-tailed); **p < .01(two-tailed); *** p < .001(two-tailed)

According to the features of the dimension of creativity curiosity, the result reflected that people with strong personality traits of creativity curiosity are always inquisitive, curious about things. What is more, they are keen on exploring things and willing to think thoroughly about things, and they may have a lot of ideas and are eager to achieve goals. Altogether, this is in line with self-efficacy of learning behavior in learning efficacy. They can make appropriate learning plans and then achieve those goals.

Then, academic achievements were taken as dependent variables, and the multiple linear regression analysis was carried out by software SPSS.19.

Under the condition of controlling variables such as age, gender, intelligence etc., creativity flexibility was still significantly positive in predicting academic performance, which indicated that the better the performance of creativity flexibility, the better the academic performance could be. Flexibility usually meant that one may possess lots of ideas while facing a single object. The result Table 3 shows the regression analysis result indicated that students with variable ideas and flexible thinking were usually more likely to achieve better results in learning.

Analysis Conclusion

It was found through the data analysis that there was a significant positive correlation between creativity risk-taking and learning efficacy, and a significant positive correlation between creativity curiosity, flexibility and academic achievements. The dimensions of creativity that could positively predict academic achievements learning or learning efficacy include three features: adventure, curiosity and flexibility. Improving creativity can

positively affect learning efficiency. Finally, elements of creativity, risk-taking, curiosity and flexibility were selecting in the design.

Table 3. Regression Analysis Result of Creativity Level in Predicting Academic Achievements

Independent variables	R ²	△ R ²	B	SE	Beta	F	P
Age	0.140	0.104	-0.192	0.248	-0.061	-0.775	0.440
Gender			-0.021	0.175	-0.010	-0.122	0.903
Intelligence			0.008	0.003	0.206	2.578	0.011*
Curiosity			0.009	0.026	0.034	0.335	0.738
Risk-taking			0.030	0.032	0.093	0.931	0.353
Flexibility			0.138	0.055	0.210	2.501	0.014*

Note. N=151, *p < .05(two-tailed); **p < .01(two-tailed); *** p < .001(two-tailed)

Construct interactive design model

There are three dimensions of creativity, which are curiosity, flexibility and risk-taking. Each of them is corresponded to different dimension features. According to the features of the dimension, study constructs a creative element design model of STEAM educational platform can be seen in Figure 2, which is expanded from designing strategy to guide platform flow, content and operation design etc.

The first design strategy is to keep users interested in exploring freely and then to keep a positive attitude towards learning. The platform is designed from the perspective of cultivating students' creativity and curiosity, giving students the space to explore freely, trying to let students find problems independently. What is more, the process of exploring problems keeps student being curious about science world all the time. In this way, students have strong ability to explore and solve problems. Searching for courses on this platform is also an exploration of learning things for students.

The second design strategy is to provide users with multiple choices and then stimulate them to do multidimensional thinking. This platform is designed to improve students' creativity and flexibility by giving them as many choices as possible, such as plentiful courses and course contents. At the same time, paying attention to diversify the interactive design, adopt a variety of interactive ways and then let students learn in the positive interaction of learning content. Students should also be inspired to born more ideas on a same problem. Because it facilitates them thinking deeply and imagining freely. Meanwhile, appropriate tips and help are given in this process if them have trouble in thinking ideas.

The third design strategy is to encourage users to challenge difficulty. This platform is designed from the perspective of cultivating users' creativity and risk-taking. It aims to set difficult challenge tasks to form "learning + training" pattern and to encourage students to try them. During the process of learning, some time-limited tasks or small tests are set up to help students review the learned content. After finishing the work, they would explain and evaluate their own works and other users' work to promote mutual learning.

Curriculum Design Model Combined with Design Thinking

The STEAM education platform provides STEAM project-based courses for school-age children aged from 10 to 12, and creativity assessment before and after class. Combining design strategy and design thinking, taking the current mainstream programming project as an example. The platform structured into 3 functional modules, 4 course stages, and 4 lessons learning as shown in Figure 3.

According to the design strategy, the STEAM education platform sets up three main functional modules: Flexible founding, Curious learning and Adventurous testing. The Flexible founding module includes four functions: course search, course screening, course recommendation, and course reservation. As the entrance to course learning of education platform, curious learning includes two important functions: content learning and course management. The course content learning also includes four course stages: discover problems, discuss the plan, make prototype and evaluate works; course management assists in management courses in different states (course reserved, course uncompleted, course completed). The Adventurous testing includes task test and scale test, test instructions, test results report. It is an effective assessment for course that measure the change of the creativity by the platform.

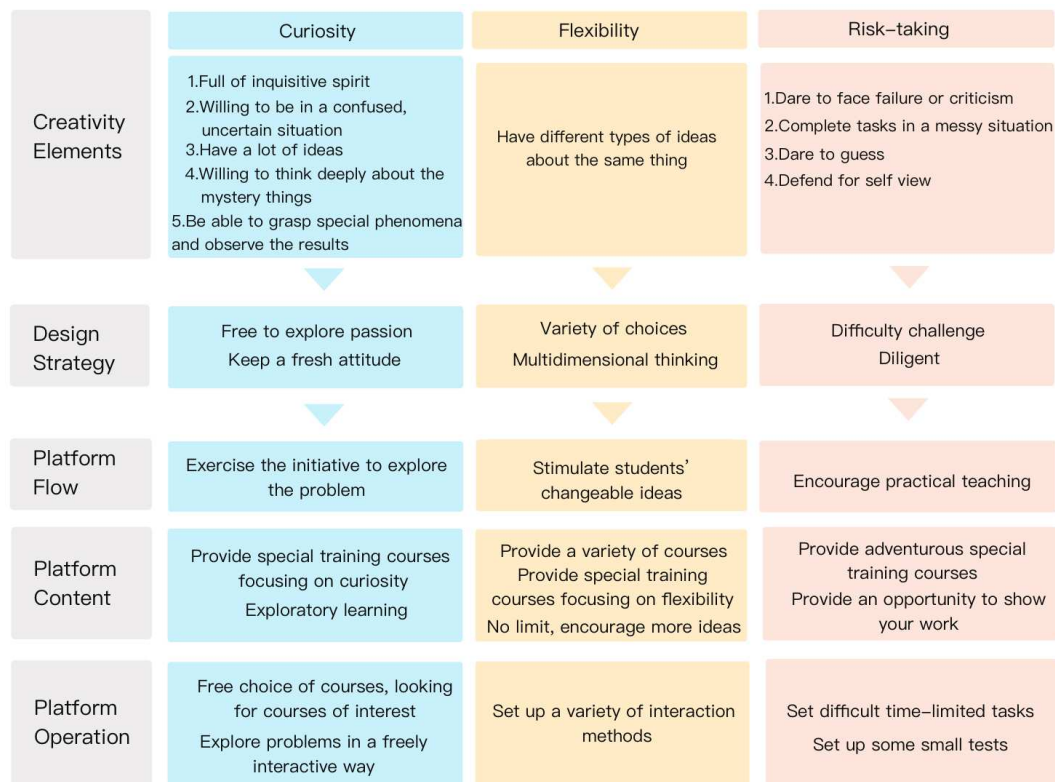


Figure 2. Creative Elements Design Model

The combination of creative elements and design thinking forms a course design model can be seen in Figure 4. The final education platform courses include curiosity inquiry, flexible thinking, adventurous attempt and mutual rating four course stages. The STEAM education platform contains multiple courses, and each course is also a project, focusing on programming learning. After each course is finally completed, a virtual work will be generated. This study applied the course model in design project example called Animal Lamp.

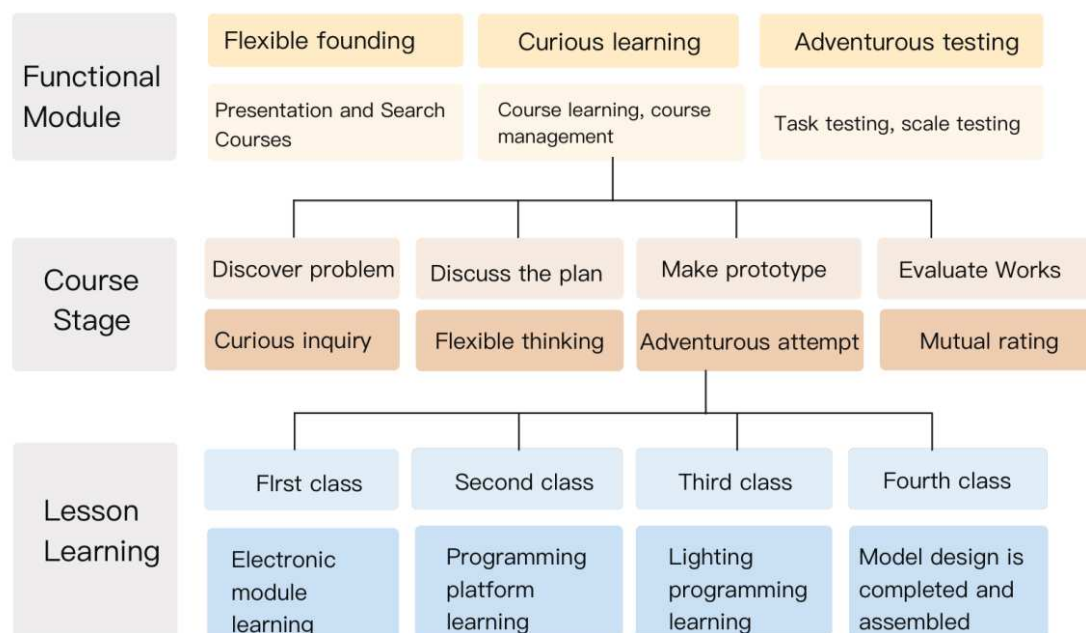


Figure 3. STEAM education platform structure diagram

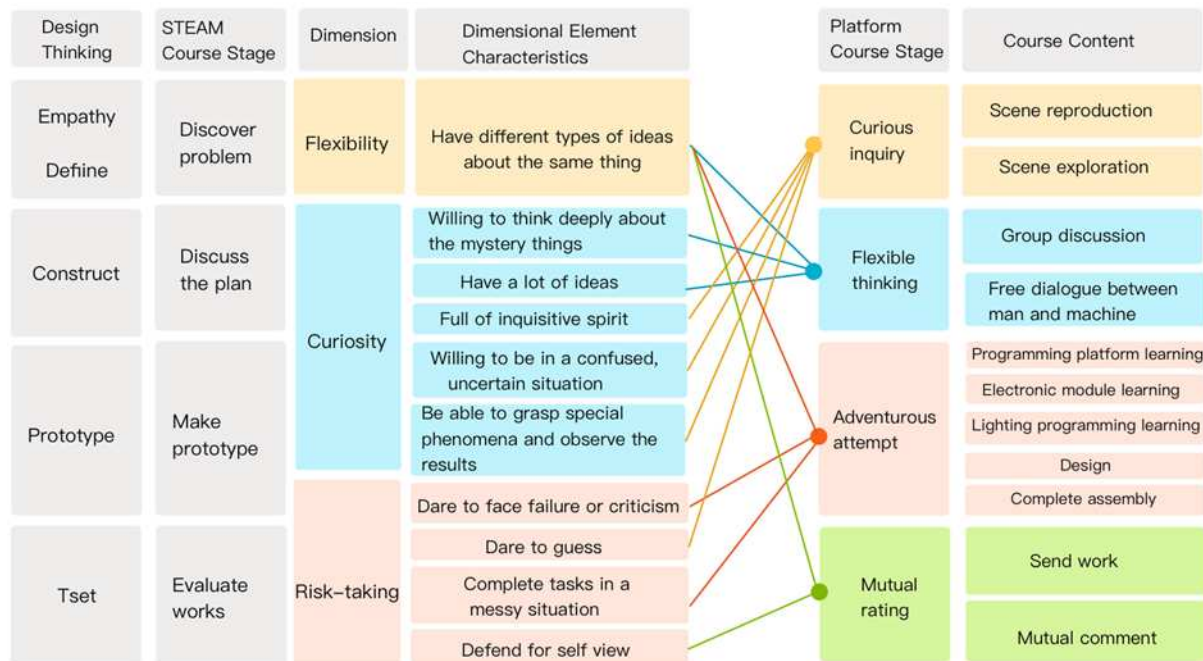


Figure 4. Curriculum design model

STEAM education platform courses are mainly in the form of online project-based learning, and the content includes interdisciplinary knowledge of science, technology, engineering, art and mathematics. The curriculum design model emphasizes the integration of design thinking and STEAM course stages, and at the same time applies creativity elements to different stages of design thinking, and finally forms different course stages. The empathy and problem definition in design thinking are consistent with the problems of the STEAM course to form a curiosity inquiry content stage, which aims to cultivate children's curiosity and adventurous characteristics. The conception in design thinking is integrated with the discussion plan of the STEAM course to form a flexible thinking content stage, which aims to cultivate children's flexibility and curiosity characteristics. The prototype design in design thinking is integrated with the prototype work of the STEAM course to form an adventure content stage, which aims to cultivate children's adventurousness and flexibility characteristics. And finally combines the testing and work evaluation stages to form mutual evaluation content stage, which aims to cultivate children's characteristics of adventurousness and flexibility.

Curious Inquiry

The content of the learning module of Curious inquiry is mainly to cultivate users' curiosity and adventurousness can be seen in Figure 5. Through scene reproduction and scene exploration, users can find problems in the provided scenes, mainly through personalized interaction. In the process of the whole scene reproduction, the users can explore the scene, choose to interact with the environment and give relevant prompts. They can also choose to interact with the task, which means having a dialogue with the task in the picture. These designs meet characteristics of letting users be full of investigation spirit and willing to contact with confused and uncertain situations. After the user discovers the problem through scene reproduction and scene exploration, they also need to guess the problem, input the problem, and determine whether the input problem is correct according to the keywords. Enter the correct key words to enter the next learning content.

Stage	Content	Personality interaction	Animal Lamp Project
Curious inquiry	Scene reproduction	Show like stop motion animation	The background of the story is that Chuangchuang Zoo opening anniversary is coming, but the director looks anxious. Platform provided user with the day and night scenes of the zoo to guide them discover problems.
		Manually select to switch the upper and lower pages	
	Scene exploration	Every element that can be interacted has a logo	1. The user can get some key information by talking with the principal, click the interactive button to continue the conversation and understand the troubles of the principal 2. Talk to the flowers, plants and animals in the garden to get their thoughts on the anniversary of the zoo, and provide auxiliary information for exploring problems
		Talk and interact with characters	
		Promptly interact with the environment (useful prompts and useless prompts)	
	Discovery problem	Enter the problem in the input box after finding the problem	Through the interaction with the zoo's flowers and plants and the director, the user explores the problem. Then needs to enter the problem description with the keyword "lack of light decoration" on the page where the problem is found to complete the task
		Contain keywords to unlock the next stage	

Figure 5. Curious inquiry stage design

Flexible Thinking

Flexible thinking requires users to think about potential solutions related to problems and topics can be seen in Figure 6. In order to train users to have flexible and changeable thinking logic about the same thing, the design gives users more freedom and allows students to try to discuss and think with other people. The interaction of people inspires new ideas, and finally comes out a solution. The main activity in this content stage is online group discussion: according to the questions discovered by the previous curious questions, you can enter a group of 3 discussion tables for free discussion according to the matching of the questions, or you can freely choose a discussion table with vacant seats. During the discussion, users can communicate by voice. If you have any questions during the discussion, you can ask the robot assistant, who can help users solve some of the problems through human-machine communication.

Stage	Content	Personality interaction	Sociality interaction	Animal Lamp Project
Flexible thinking	Group discussion	Select system matching group	Voice and text communication	Choose the discussion table and discuss the solution of the problem
		Choose free grouping		
	Free talk with machine		Ask the robot for help	After entering the idea for many times and failing the verification, you can ask the robot to give some hints
	Confirm idea	Enter and record your thoughts		It is necessary to verify the proposed ideas, and the keywords of animal lamp can be passed at end the discussion

Figure 6. Flexible thinking stage design

Adventurous Attempt

Adventurous attempt is the process of prototyping, using a pattern of "learning + training" can be seen in Figure 7. All platform projects are programming related projects, because programming learning came into educators' attention in recent years. Users need to learn how to use electronic modules and programming platforms, as well as basic graphical programming principles and operations. Taking risks is the key point in the content of the platform. In order to facilitate students' understanding and learning abilities, the content is systematically formed into four class hours, and the content will be adjusted according to the project. The four

class hours belong to the basic learning and each project will be matched accordingly. Among them, the knowledge of the programming platform in the second class is the content of general learning. If students have learned in the previous project, they can skip this part, but students cannot skip the other learning contents of the past project. They should study them in order.

Stage	Content	Personality interaction	Sociality interaction	Animal Lamp Project
Adventurous attempt	Electronic module learning	Interact with the different components of the module	Barrage and simultaneous users Ask each other questions and answer each other	Learning of the main control module and LED light screen module
	Programming Platform Learning	Interact with different areas of the programming platform		General knowledge of programming and programming platform
	Programming Learning	Interact with programming blocks		Lighting programming learning
	Modeling Design Complete Assembly	Interaction with the module, personalized painting design		Comprehensive study, animal appearance art design

Figure 7. Adventurous attempt stage design

Mutual Rating

After completing the production and testing the prototype, users entered the stage of mutual comment on works can be seen in Figure 8. The stage of mutual evaluation includes transferring works. Users are required to name their own virtual works, and then upload the works to the course portfolio; to evaluate others works and view comments on their own works, each user needs to evaluate at least two works. The purpose of the design at this stage is to make sure that users can exercise adventurous defense on their own opinions and have flexible characteristics and flexible ideas for treating the same things in flexibility.

Stage	Content	Personality interaction	Sociality interaction	Animal Lamp Project
Mutual rating	Send work	Edit the title and introduction of the work		Upload your own animal lamp works
	Mutual comment		Comment on other people's work	Choose other animal lamp works
	View and reply to comments		View and reply to other people's comments on your work	Enter my work page to operate

Figure 8. Mutual rating stage design model

Discussion

Conclusion

STEAM education aims to improve students' innovative ability and at the same time cultivate students' creative problem-solving ability. Design thinking is also a way of thinking that exercises creativity. So, creativity, as an important element, can promote the further integration of STEAM education and design thinking. According to the results and the practice of design, we can conclude three conclusions. Firstly, the article found creative elements that have an impact on learning through quantitative analysis. These elements as well as have an impact on STEAM education. These creative elements are representative and therefore more suitable for education-related design. Secondly, the design practice of the platform proved that these design models can well integrate design thinking and STEAM education. The characteristics of creative elements play important roles on better guiding the design of the STEAM education platform. Thirdly, design models can well overcome the problems of no breakthrough point and difficulty in quantitative evaluation when design thinking is integrated with STEAM education. Through the creativity test, it can further verify the effect of design thinking on STEAM education. This paper proposes an innovative method for later design thinking to solve the challenge of education integration. Creativity can be as evaluation indicators to assess course effect before and after the course.

Limitation

Some limitations need to be acknowledged and further work needs to be conducted to address them. Firstly, the STEAM education platform model and curriculum design model request more design practice to check them validity but we only employed them into one course case. Because course development requires a long period, the number of courses developed using model practice design is limited. In the future study, we can apply it in multiple courses to design STEAM education platform and curriculum. Secondly, the small sample size of this study prevents us from generalizing the findings to a broader population, and as well as ignored the comparison measurement of children's creativity change before and after the course. Thirdly, since ways are diversity which design thinking can be applied to innovation education, this article only explored creativity elements related study how to help design thinking integrated into STEAM education. Other key points of STEAM education are also worthy of our in-depth thinking and exploration. A further study is also proposed to complete this study.

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Inclusive education driven by design

The case of a graduate seminar course

Úrsula Bravo and Maritza Rivera

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This case study explores the use of design tools by educators with an aim to answer the question: How can a design-based approach contribute to the development of strategies for inclusive education? Thirty-five educators, who were students from the final year of a master's degree focusing on inclusive education taught at a Chilean university, participated in the study. The information collected included participant observation and the analysis of the work elaborated by the educators throughout the seminar. Subsequently, we selected the trajectories of three participants, which were analysed by open coding. The results suggest that adopting a design-based focus helped the educators understand pedagogical problems as systems of relationships, frame problems constructively, think visually about possible teaching strategies and develop didactic materials to respond to the special educational needs of their students. These findings are important in the light of inclusive education policies that seek to ensure the regular education system provides learning opportunities for all students, regardless of their physical or intellectual characteristics.

Keywords: inclusive education, design-based approach, teacher professional development, special educational needs

Introduction

Inclusive education is that which gives access to quality education to every child. Its three basic premises sustain that: i) every child count (UNESCO, 1994), ii) an educational system should be able to create opportunities for each one, and iii) the learning environment should welcome, protect and educate each child regardless of their gender and physical, intellectual, economic and linguistic characteristics, among others (Ainscow, 2014). In the Chilean context, Decree N°83 (Ministerio de Educación, 2015) promotes the implementation of measures that give curricular flexibility and universal accessibility (Meyer, Rose & Gordon, 2014) to meet the need of students with special educational needs (SEN) in early years and primary education. However, 38% of educational establishment directors declare a lack of inclusive education teaching skills in Chile (Thomson & Hillman, 2019).

In search of a response to this need, a graduate programme focused on inclusive education at a Chilean university decided to incorporate design-based methods and tools. The programme assumes an anthropological perspective of otherness, which conceives differences as individual features of people. The programme defines itself as essentially interdisciplinary and professionalizing. Interdisciplinary training provides a comprehensive and integral vision of learning by considering the students' context, not just their learning condition or difficulty. The curriculum includes a set of disciplines that address diversity at all educational levels. Moreover, the teaching team is made up of professionals from early years, primary and special education, as well as others from psychology, speech therapy, occupational therapy, neuropsychiatry, public policy and design.

Design as a strategy for situated problem-solving in a school context

The decision to include design tools and methods seeks to develop higher professional competencies that enable the master's students to solve educational problems in context by designing and implementing



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pedagogical strategies that support the inclusion of people with SEN into the regular school system. These strategies are understood as a set of teaching tools that allow interaction with the students that encourages their participation, motivation and interest, in order to achieve learning (Pérez & Salamanca, 2013). Authors such as Simon (1996) and Schön (1998) have addressed the link between design and professional development. The former suggests that all professionals design when they carry out actions that seek to change existing situations into desirable, but as yet non-existent, situations. For his part, Schön suggests that design can serve as a model for professionals in other areas to develop skills in framing and solving complex problems. This would explain the growing use of design-based methods to address complex problems and encourage innovation in various contexts, including teacher training. At the early years education level Jordan (2016) observes that a design-based focus helps trainee teachers to be more flexible, more adaptable and more open to explore. While Henriksen, Richardson and Mehta (2017) have observed that approaches based on design, like so-called design thinking, provide an accessible structure that empowers teachers to creatively address the wide variety of problems they must solve daily. Evidence is still limited and focused on small groups, but it is possible to foresee that adopting a design perspective could be of great value to Chilean educators in light of inclusion (Manghi et al., 2020) and professional development policies that demand large doses of flexibility and creativity on the part of teachers. Precisely, this case study analyses the contents, methodology, and results of the course “Seminar on innovation for diversity in school” offered as part of a master’s degree course focused on inclusive education. This course incorporates a design perspective that seeks to answer the question; How can a design-based approach contribute to the development of strategies for inclusive education?

Seminar on innovation for diversity in school: objectives, contents and techniques

The master is taught face-to-face at a Chilean university. It lasts three semesters and is targeted at education professionals who work in public or private institutions. The final degree project is carried out in the context of the “Seminar on innovation for diversity in school”, which consists of 130 teaching hours. In this project, the master’s students –henceforth “educators” to distinguish them from the recipients of their projects– integrate and put into practice the knowledge and skills acquired in the programme through the design and testing of an inclusive education strategy aimed at an individual or group of students. The seminar is divided into three stages. The first two are oriented at developing an integral evaluation of the student(s) and the third at developing the strategy.

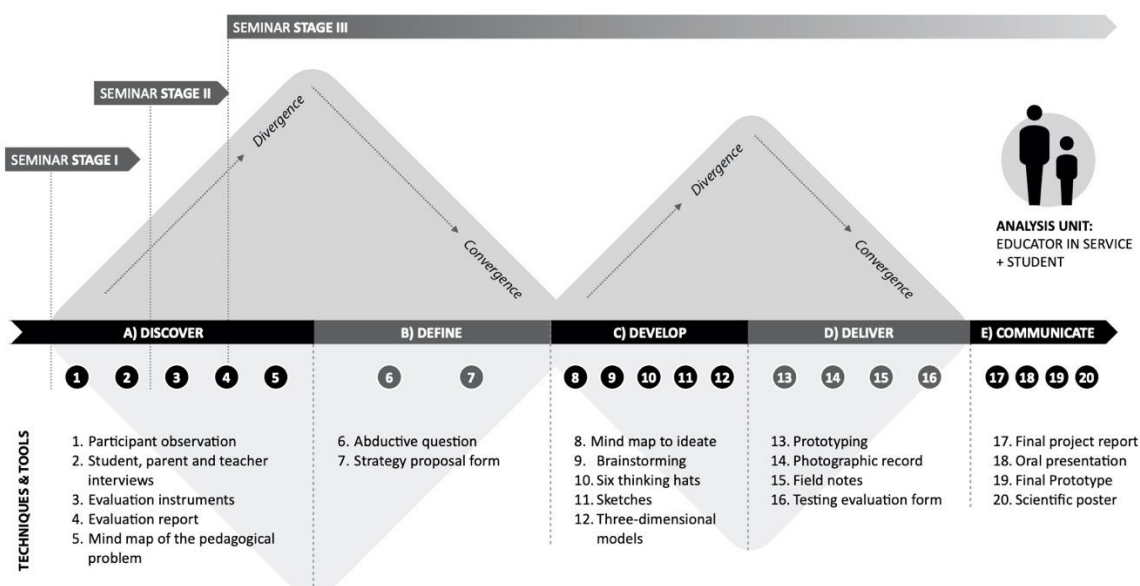


Figure 1: The Double Diamond integrated into the seminar’s three stages

The seminar adopts the Double Diamond design model proposed by the United Kingdom’s Design Council (Design Council, 2021). This model aims to guide designers and other professionals to address complex social problems through cycles of divergence and convergence oriented at a) discovering or identifying a problem, b)

defining the problem as a design challenge, c) developing ideas that respond to the challenge and d) delivering or testing different solutions on a small scale to evaluate and improve the proposal. In addition, the seminar incorporates: e) communicating the final solution. The following sections will describe the three stages of the seminar and their articulation with the Double Diamond, as summarised in figure 1.

a) Discover

The first two stages of the seminar focus on *Discover*. In the first stage, the educators start by observing their students in the educational establishment where they work to identify SEN and choose the recipient of their pedagogical strategy. This is followed by (1) *participant observation* and (2) *interviews with the student's teachers and parents* to identify barriers or facilitators in the learning process both at school and home. In the second stage, the educator evaluates the student's performance, both in the cognitive and the psychomotor and socio-affective areas, to determine more precisely what the student's SENs are. To do so, the educator applies several formal and informal (3) *psycho-pedagogical evaluation instruments*. The second stage ends with a comprehensive socio-educational evaluation in the form of a (4) *report*. This input marks the beginning of stage III of the seminar, the objective of which is to design and test an inclusive educational strategy. Stage III begins with the educators drawing a (5) *mind map of the pedagogical problem* using the information from their report. Designers' ability to visualize the whole process has been widely recognized as a way of thinking and creating and communicating ideas (Cross, 2013; Kolko, 2011). That is why the seminar uses mind maps, diagrams, sketches and models in the different stages of elaboration of the pedagogical strategy. This first mind map aims to visualize the pedagogical problem as a complex system composed of different interacting elements: the student – his or her strengths, difficulties and interests – the school and the family. The student's name is placed at the centre of the sheet, with all the other elements branching out from it. In this way, it is possible to establish relationships between distinct elements that make up the system and need to be taken into account when designing the inclusive support strategy.

b) Define

Schön (1998) has suggested that problems are not presented to professionals as an a priori external reality. On the contrary, professionals interpret a situation that they judge to be incomprehensible, worrying or uncertain as problematic. They must "frame" the situation, clarifying the results they hope to achieve with an intervention, stating the means they will use to reach it and conjecturing a possible solution. This type of reasoning, known as abductive, is related to the capacity to speculate and make conjectures; that is to say, it suggests that something can or might come to be (Cross, 2013). Precisely, to facilitate the definition of the design challenge, educators use what we have called an (6) "*abductive question*", which is a first-person interrogative conditional: "How might we... to...?" (IDEO, 2012). In addition, the educators use (7) *forms* that help them progressively define the objectives, activities, resources and evaluation indicators of their strategy. Both the question and the forms are repeatedly revised and adjusted as the proposal is finely tuned.

c) Develop

To create ideas that respond to the design challenge, the educators use techniques to stimulate creativity, such as the (8) *mind map to ideate* and (9) brainstorming. Following this, they evaluate and select the best ideas using the (10) *six thinking hats technique* (De Bono, 2017). The mind map to ideate is organized around the abductive question. It includes information about the student, his or her context and ideas for developing the pedagogical strategy and the learning results that need to be reached through its implementation. In addition, the educators use (11) *sketches* and (12) *three-dimensional models* to communicate their ideas to their instructors and peers. This is done progressively and iteratively, contrasting ideas with the socio-educational evaluation report, the mind map of the problem, the abductive question and the forms. If necessary, they adjust the question and update the form.

d) Deliver

The selected ideas materialize in (13) *prototypes* that are tested out on the student or target person in their school or family context. This allows the formal and pedagogical aspects to be checked, and if necessary, changes that improve the proposal can be applied. The educators observe the students interacting with the prototypes and take (14) *photographs* and (15) *field notes* for support. The conclusions are summarized in a (16) *test evaluation form*.

e) Communicate

The seminar finishes with a (17) *final report* and an (18) *oral presentation* showing the (19) *final prototype*, and a (20) *scientific poster* with a summary of the objectives and characteristics of the inclusive education strategy.

Methodology

This case study explores in-service educators' use of design methods and tools during the final seminar of a graduate course that aimed to answer the question: *How can a design-based focus contribute to the development of inclusive education strategies?*

The study involved 35 students from the 2016 and 2017 cohorts who attended the "Seminar on innovation for diversity in school" of a master's degree focusing on inclusive education taught at a Chilean university. All the participants were working educators, the majority being teachers, although there were also psychologists and speech therapists.

The information collected included participant observation by the researchers, who at the same time are teachers of the seminar, and the analysis of the work elaborated by the educators throughout the seminar, such as reports, forms, graphic and photographic material. Subsequently, we put together thick descriptions of the trajectory of three of the participants, which were analysed by coding with emerging categories. The selection criteria for these three participants included that they had carried out a detailed register of their trajectories' different stages and that a wide range of cases were covered between the three of them, including different education levels and pedagogical problems.

Results

The results of the study have been organized into two sections. The first summarises the pedagogical problems and the proposals of the three selected participants, while the second presents the study's principal findings.

Pedagogical problems addressed by the participants

SEN associated with a global development disorder in a girl in early years education

"How might we enhance the sensory and perceptual skills of a 3-year-old girl with Down syndrome in order to improve her communication skills?"

Juanita is an early years teacher who works in a public nursery school. One of her pupils is a three-year-old girl with Down syndrome. The evaluation shows decreased sensory and perceptual skills, language expression and comprehension difficulties, poor stimulation from her family and a lack of pedagogical strategies targeted at the girl's needs at school. Juanita hypothesizes that a pedagogical strategy focused on strengthening sensory and perceptual skills that develop communicative competencies through play will contribute significantly to the girl's development. With this aim in mind, Juanita designs a box of sensory material that has two stages. The first targets the exploration of material stuck to the outside of the box, while the second seeks to encourage semantic and phonological skills through images of everyday objects and short stories.

SEN associated with a language disorder in a boy in primary school

"How might we enhance the development of Ale's meta-phonological skills in order to improve his initial literacy?"

Carolina is a speech therapist who works in a Special Language School. One of her pupils is a six-year-old boy who shows great interest in the military world. The evaluation here shows that a language disorder is hindering the boy's initial literacy. The family has few tools to help his process, while the school's contribution has been hampered by his poor class attendance. Carolina designs a strategy to strengthen the development of his meta-phonological skills and improve his initial literacy. With this goal in mind, she designs a board game called "Soldier Ale" made up of a board with six military missions based on literacy skills. During the game, the boy uses soldier figures to go through each stage, and on reaching the goals, he is awarded medals. The game comes with instructions for his parents so they can support him.

SEN associated with reading comprehension difficulties in a woman deprived of liberty

"How might we strengthen reading comprehension and writing skills to improve education opportunities oriented at the world of work?"

Hernán is a primary teacher who works in a prison. His student is a 57-year-old woman who never completed her primary education and is now deprived of liberty for drug trafficking. The evaluation shows learning difficulties in the language area, especially in reading comprehension. Hernán's strategy proposes a School Progress Log. This log provides a hard copy of support that makes the student's progress visible by recording the activities carried out, the student's self-assessment and the teacher's feedback. This strategy seeks to favour the student's metacognition to keep her motivated during her learning process and avoid her dropping out.

Principal findings

Understanding the problem as a system of interrelationships in which the student is at the centre.

The use of mind maps throughout the different stages of the seminar proved to be an effective way for educators to understand the pedagogical problem better and identify opportunities.

In the first mind map, the spatial organization of the information allowed all the intervening factors to be represented simultaneously and with the same level of importance. In this way, barriers and facilitators at the school and family level were juxtaposed with the student's characteristics, interests and educational needs. This broke the lineal logic of educational assessment, which tends to focus on the deficits without considering the student's interests or skills, elements that can provide important opportunities for the design of the pedagogical strategy.



Figure 2: Carolina's mind map for the pedagogical problem

For example, in Carolina's mind map for the pedagogical problem (figure 2), the boy's interest in the military imaginary is represented by the thick blue line, which in visual terms is almost as important as the information about his SEN (the red line). The drawing of the light bulb indicates that this topic emerges as an opportunity to be used as a motivational resource, which was transferred onto the mind map to ideate that included words like "game", "tin soldier", and "medals" (figure 3). Subsequently, the military theme transformed into a crucial element of the pedagogical strategy.

Framing the problems constructively and in first-person

Formulating the pedagogical problem in terms of a design challenge and using a first-person interrogative conditional positioned the educators as active agents and not mere observers of “somebody else’s” problem. In addition, it allowed them to map out a pedagogical goal without losing sight of the wider purpose, namely contributing to the student’s educational inclusion. With her challenge question – How can we enhance the sensory and perceptual skills of a 3-year-old girl with Down syndrome in order to improve her communication skills? Juanita hypothesized that strengthening the girl’s sensory and perceptual skills would improve her communication with her environment, which in turn would produce better quality interactions that would contribute to her development.

Ideating, materialising and testing ideas through drawings and models

Making models or prototypes and having the target people –the students, their teachers, family members– manipulate them was a key activity. It allowed the educators to evaluate their proposals and make necessary adjustments to achieve a strategy in accordance with the conditions of use of the material. For example, Juanita’s final proposal was a box of sensory material made up of two stages. The first stage aimed at the student exploring and manipulating the material stuck to the four exterior sides of the box. The second sought to improve the girl’s semantic and phonological skills. To achieve this result, Juanita made different prototypes that she tested with the girl in the nursery school. In the first test, she observed the size, colour and materiality of the box, the manipulation of elements such as buttons and zips and how the material motivated the girl. Testing out the box allowed her to see problems related to an excess of visual stimulation and difficulties in manipulating some objects due to their size or position. Juanita corrected these aspects in her second prototype by adjusting the material and the sequence of activities (figures 5 and 6).



Figure 5: Developing different prototypes



Figure 6: Photographic record of Juanita’s testing

Discussion

Our research addressed the question: How can a design-based approach contribute to the development of strategies for inclusive education? In this regard, we can affirm that design provided tools for in-service educators to frame an educational problem in a contextualized manner and design a pedagogical strategy focused on the SEN and interests of a student, as well as the conditions and context of the family and the school. In this way, the educators complied with the fundamental premise of inclusive education, namely that the regular education system must welcome all students and create learning opportunities for each one, regardless of their condition (Ainscow, 2014).

In the same line of inclusive education (UNESCO, 1994), design provided a global and integrating vision through visual thinking. This allowed the educators to redefine a specific pedagogical problem and find new relationships between the elements involved, which were interpreted as opportunities to create situated pedagogical responses. In this way, they managed to ideate a pedagogical strategy and design a didactic resource relevant to the user because they took into account his or her learning potential, preferences and interests and individual and collective needs. This allows us to affirm that design thinking provided support that enabled the in-service educators to creatively face a wide variety of pedagogical problems (Henriksen et al., 2017).

What initially were considered barriers to learning in the evaluation were understood as design requirements after using a design approach. This was evidenced by the transformation of impediments into access to learning through the pedagogical strategy and the didactic material. In this sense, design allowed educators to transfer what they had learned in the approach and resolution of complex problems so fostering innovation and contributing to their professional development (Schön, 1998).

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Measuring the Impact of Integrating Human-Centered Design in Existing Higher Education Courses

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The purpose of this research is to describe the development of a survey that can be used to measure the impact of integrating Human-Centered Design (HCD) on students' knowledge of performing its processes in existing higher education courses. The survey was developed based on a research-based HCD taxonomy that outlines the design spaces, the processes, and practices that define what it means for students to implement HCD within the context of k-12 or higher education settings. The survey consisted of 23 items and was pilot tested with 46 students. Validity and reliability analyses were conducted, and the survey items were revised in light of the findings. More items were also added to the existing survey. The development and use of this survey can promote efforts of scaling the integration of HCD in existing higher education courses.

Keywords: human-centered design, survey, higher education

Introduction

Human-Centered Design (HCD) is a problem-solving approach that identifies the unmet needs of a population in order to collaboratively and iteratively develop solutions (Brown, 2008). In the past decade, there has been an increasing trend of teaching and learning HCD in higher education settings (Ching, 2014; Kumar et al., 2020; Lin et al., 2020) given its promising potential to prepare students for engaging effectively in future learning endeavours and participating actively in solving today's global challenges.

Several research studies show that when students engage in learning and implementing HCD processes, they develop 21st century skills such as solving complex problems and working in multidisciplinary teams (Koh et al., 2015; Noweski et al., 2012). Eventually, as students practice these skills, they develop critical mindsets, such as human-centeredness, metacognition, collaboration, experimentation, communication, and creativity (Goldman et al., 2012; Razzouk & Shute, 2012). These mindsets are essential for design and non-design students to become lifelong learners and successfully solve personal and work problems. However, providing students with opportunities to learn and implement HCD processes within the context of higher education courses is challenging (Kumar et al., 2020; Shehab et al., 2021a). One reason for that is our lack of the knowledge of how to effectively integrate HCD in existing higher education courses that are usually subject to many curricular and time constraints. Specifically, little is known about evaluating the impact of integrating HCD on students' knowledge of performing the HCD processes in these courses.

To address this gap, we report how a newly established design center continued to integrate HCD in existing higher education courses at a large Midwestern university. Specifically, in this paper, we describe how we built on the evaluation of our first iteration of integrating HCD in three existing courses (Shehab et al., 2021a) to design a survey that can measure the impact of integrating HCD on students' knowledge of performing the HCD processes. Findings from this work can promote efforts of scaling the integration of HCD in higher education courses by enriching our knowledge of how to effectively measure the impact of HCD activities on students' knowledge of performing its processes in existing higher education courses.



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What is Human-Centered Design?

Human-Centered Design is a problem-solving approach that identifies the unmet need of a population in order to collaboratively and iteratively develop solutions (Brown, 2008). HCD puts humans at the center of the design processes and seeks to establish empathy with them, understand them, collaborate with them in order to identify their problems and figure out solutions (Brown & Katz, 2011; Dorst, 2011; Zhang & Dong, 2008). Then, HCD relies on iterative cycles that engage humans in prototyping, testing, and refinement of solutions (Brown, 2008). HCD provides a flexible structure that can guide the processes of solving wicked problems (Buchanan, 1992; von Thienen et al., 2014) and generate creative and meaningful solutions (Meinel et al., 2020). HCD should not be viewed as a predefined sequential series of processes that one initiates to solve a problem; nevertheless, it is best described as “a system of spaces” (Brown, 2008, p.4). Each space consists of processes such as empathize, organize, brainstorm, create, and develop which can be executed by learning and implementing practices such as interviewing people, identifying themes, communicating ideas, creating prototypes and developing plans to bring final designs to the market (IDEO, 2015). Figure 1 shows the HCD taxonomy that summarizes the human-centered design spaces and processes (Lawrence et al., 2021). The definitions and the practices associated with each process are defined in Lawrence et al. (2021).

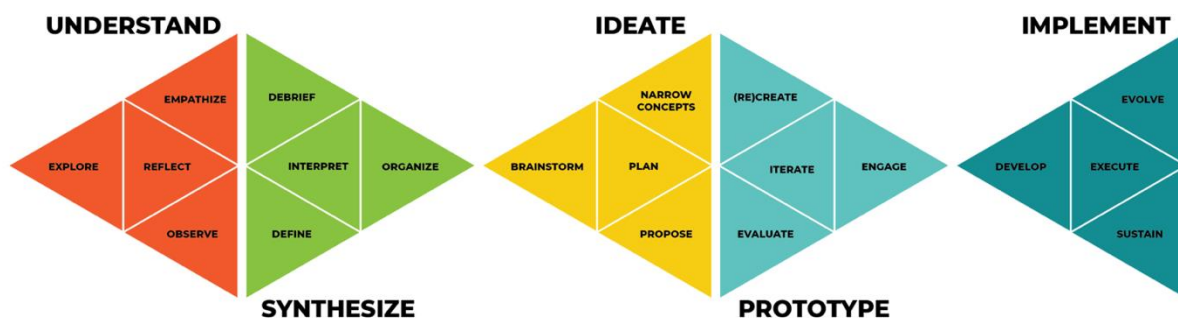


Figure 1. The Human-Centered Design Taxonomy spaces and processes (Lawrence et al., 2021)

Human-Centered Design in higher education settings

Given that HCD is an approach for solving wicked problems and generating innovative solutions, researchers argue it is not only for designers (Johansson-Sköldberg et al., 2013; Wrigley & Straker, 2017). Non-designers can also benefit from implementing and acquiring these processes and practices as they help them develop skills that make them lifelong learners and prepare them to solve complex problems in different contexts (Goldman et al., 2012; Meinel et al., 2020; Razzouk & Shute, 2012). For example, HCD processes and practices engage individuals in finding, discerning and analyzing resources, creating arguments, problem-solving, building and testing models, storytelling, managing time, persisting, and working in teams (Johansson-Sköldberg et al., 2013; Panke, 2019). As individuals learn and practice these skills, they may eventually develop human-centered, metacognitive, collaborative, experimental, creative, and communicative mindsets (Crismond & Adams, 2012; Culén & Gasparini, 2019; Goldman et al., 2012; Razzouk & Shute, 2012; Royalty, 2018). These mindsets match with what employers seek in 21st century employees (Jang, 2016; Prinsley & Baranyai, 2015). In light of that, universities are increasingly investing in integrating HCD in their programs as means for students to experience and develop these mindsets in addition to disciplinary knowledge (Lake et al., 2021; Wrigley & Straker, 2017).

One way to bring HCD to university programs is through integrating it in the content of existing courses, especially those that require students to complete a research or design project over the duration of the semester. In such courses, HCD can serve as a tool for students to complete the project while learning and implementing processes that assist them to a) identify real problems and figure out meaningful solutions that are directly connected to their experiences beyond the course b) learn and practice skills that are essential for developing 21st century mindsets such as collaboration and communication, and c) acquire an understanding of the underlying disciplinary concepts associated with the course. The integration of HCD in these courses is supported by the constructivism learning theory that emphasizes the fundamental roles of prior knowledge, experiences, and social interactions in students' learning processes and outcomes (Bada & Olusegun, 2015; Sjøberg, 2010). Researchers argue that learning and implementing HCD processes enhances students' engagement in constructing knowledge and thought processes using their prior knowledge and experiences and through social interactions which can result in better learning outcomes (Luka, 2020; Pande & Bharathi,

2020; Scheer et al., 2012). Nevertheless, only few studies report on how to effectively integrate HCD in existing higher education courses (Ching, 2014, Pagano, Shehab, & Liebenberg 2020, Shehab et al., 2021a). In addition, little is known about measuring the impact of integrating HCD on students' knowledge of performing its processes in these courses.

The purpose of the current research

The purpose of this research is to describe how a newly established design center at a large Midwestern University developed a survey that can be used to measure the impact of integrating HCD on students' knowledge of performing its processes in existing higher education courses. This survey can be useful for researchers to evaluate the impact of an HCD intervention on students' knowledge of performing HCD processes. Moreover, the survey can be useful for teachers, especially those teaching classes with large number of students, to assess how integrating HCD activities assisted students (or not) in acquiring HCD processes that they may find useful to solve problems beyond the course.

Methods

This research is part of a broader design-based research (McKenney & Reeves, 2012) initiative led by a newly established design center at a Midwestern University. Members from the Center collaborate with instructors across disciplines to explore and harness opportunities of integrating HCD activities into their courses.

Survey development

In the Spring 2019 semester, members from the center collaborated with three instructors to integrate HCD in three different existing courses. The evaluation of integrating HCD in these courses from the students' and instructors' perspectives indicated the need for tools that can assist instructors in communicating what HCD is and ways to measure students' performance and acquisition of the HCD processes (Shehab et al., 2021a). In response, research members from the center developed a research based HCD taxonomy that is shown in Figure 1 (Lawrence et al., 2021). Drawing from the HCD literature, the taxonomy outlines five design spaces, the processes, and practices that define what it means for students to implement HCD within the context of a k-12 or higher education setting. For example, in the Understand space, students try to identify the problem through connecting with the users and thinking about their assumptions and biases. The Understand space is composed of four core processes: Explore, Observe, Empathize, and Reflect. Therefore, for students to Understand the problem, they need to learn and implement the practices associated with each of the four core processes. For example, to Empathize, students need to learn about locating resources, conducting interviews and identifying extreme users; then, they need to implement these practices to make progress on their research or design project.

In the Fall 2019 semester, members from the center collaborated with two instructors to integrate HCD in two different existing courses. The duration of both courses was 16 weeks and they both included a design project that students needed to complete by the end of the course. One course was a technological entrepreneurship course and the other was a food science course. In both courses, the taxonomy was used as a tool for teaching and learning about HCD as a problem-solving approach with processes and practices that students can implement to complete the design project over the duration of the course. The members from the center and each of the instructors co-designed and engaged students in activities to acquire the HCD processes and practices outlined by the taxonomy and implement them to make progress on their design project. The research members from the center needed an instrument to measure the impact of these activities on students' knowledge of performing HCD processes in these courses. They developed a self-administered survey that can be used prior and post any existing course that integrates HCD.

The survey was a 5-points Likert Scale with 1=Strongly Disagree and 5 = Strongly Agree. The items of the survey were developed based on the definitions and practices that are associated with each of the 20 processes that were outlined by the HCD taxonomy based on the HCD literature. The survey had 23 items. Nine items were associated with the processes of the Understand space, three items were associated with the processes of the Synthesize space, four items were associated with the processes of the Ideate space, three items were associated with the processes of the Prototype space, and four items were associated with the processes of the Implement space. The items of the survey are shown later in Table 1.

Participants

A pilot test of the survey was conducted with the students of the two courses. A total of 46 students completed the survey as a pre and post survey prior to and at the end of the course respectively. Using data

from the pilot test, we conducted paired sample t-tests to measure the impact of integrating HCD activities on students' knowledge of performing its processes. We ran a paired sample t-test for each item and for all items associated with the processes of each of the five HCD spaces.

Survey validation

To ensure content validity, experts in HCD were consulted and their input was used to modify some items. We also used data from the pilot test to assess two important qualities of surveys, accuracy and consistency, by considering the survey's construct validity and reliability. Construct validity refers to the extent the survey items measure what they were designed to measure (O'Leary-Kelly & Vokurka, 1998). There are two types of factor analysis to measure the construct validity: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Because we intent to test whether items could measure students' knowledge of performing processes associated with pre-determined spaces, we conducted confirmatory factor analysis for each item of the pre- and post-survey to examine the construct validity of the survey. To do so, we used lavaan in the R statistical programming language. When testing the model fit, lavaan outputs different fit statistics, we only focused on two commonly used measures: Root Mean Square Error of Approximation (RMSEA) and Confirmatory Factor Index (CFI). As a rule of thumb, a model indicates a good fit when the RMSEA is close to 0.05 but smaller than 0.1 and CFI is greater than 0.90. Reliability refers to the extent the survey items associated with the processes in each space are consistent (Tavakol & Dennick, 2011). We examined the reliability of the survey by computing Cronbach's alpha per each HCD space of the pre- and post-survey. A general acceptable Cronbach's alpha value is from 0.45 to 0.98, and 0.7 or larger indicates a good level (Taber, 2018).

Results

Paired sample t-tests results

To measure the impact of integrating HCD activities on students' knowledge of performing its processes in the two existing higher education courses, we used R to conduct paired sample t-tests. The null hypothesis assumes the mean difference between two sets of observations is zero. When the p-value from the result was smaller than 0.05, we concluded that the difference in the response to an item between pre- and post-survey was significant. Table 1 shows the result of the paired sample t-test for each survey item. All p-values are smaller than 0.05 indicating a significant improvement in students' knowledge of performing the HCD processes.

Table 1. Paired sample t-test per item

Space	Pair	Item	t-value	Sig. (2-tailed)
Understand	1	I know how to develop goals for the project.	-6.75	.000
	2	I know how to review information that is related to the context of the project.	-7.164	.000
	3	I know how to document biases and predictions.	-4.388	.000
	4	I know how to conduct interviews with users.	-8.871	.000
	5	I know how to conduct observations that can inform my understandings of the users' needs.	-7.485	.000
	6	I know how to locate resources that are associated with the project.	-2.979	.005
	7	I know how to identify extreme users.	-9.513	.000
	8	I know how to reflect on my biases.	-3.392	.001
	9	I know how to reflect on the projects' motivations and stakeholders' needs.	-5.051	.000
Synthesize	10	I know how to filter content for relevance and prioritize information.	-4.463	.000
	11	I know how to find themes and develop insights.	-5.745	.000
	12	I know how to identify design and research opportunities.	-4.676	.000
Ideate	13	I know how to come up with ideas for potential solutions to a problem.	-3.341	.002
	14	I know how to break down a problem into smaller actionable parts.	-3.747	.001
	15	I know how to develop a plan of action to solve a problem.	-4.505	.000
	16	I know how to come up with alternative solutions to a problem.	-4.129	.000
Prototype	17	I know how to create a prototype.	-5.521	.000
	18	I know how to communicate a proposed prototype to others.	-5.896	.000
	19	I know how to evaluate a prototype.	-4.638	.000
Implement	20	I know how to communicate a final design.	-6.556	.000
	21	I know how to develop a plan to execute a final design.	-5.874	.000
	22	I know how to create a functional iteration of a concept.	-6.627	.000
	23	I know how to plan for the sustainability of a final design.	-7.101	.000

Following the same analysis procedures, Table 2 shows the result of the paired sample t- test for each HCD space. All p-values are also smaller than 0.05 indicating significant improvement in students' knowledge of performing the HCD processes associated with each of the five HCD spaces.

Table 2. Paired t-test for each space

Pair	Space	t-value	Sig. (2-tailed)
1	Understand	-10.277	.000
2	Synthesize	-6.281	.000
3	Ideate	-5.534	.000
4	Prototype	-5.990	.000
5	Implement	-8.75	.000

Validity and reliability test results

To assess validity, we calculated the confirmatory factor index (CFI) and the Root Mean Square Error of Approximation (RMSEA) for the pre and post surveys (see Table 3). For pre-survey, both the CFI and RMSEA values indicated that the model was not fit. For post-survey, the CFI and RMSEA values were better than the pre-survey, however, the model was still not fit. This indicated that the items of different spaces may need further modifications, so they measure exactly what we want them to measure.

Table 3. Assessment of survey validity

Survey	CFI	RMSEA
Pre	0.693	0.13
Post	0.827	0.095

To assess reliability, we used Cronbach's Alpha to measure the consistency of the survey items per each of the five spaces. Based on the values of Cronbach's Alpha shown in Table 4, both the pre- and post- survey have a

significant Cronbach's alpha for items associated with the processes of the Understand, Ideate, Prototype and Implement spaces. However, for the Synthesize space, Cronbach's alpha for post-survey was lower than 0.6, which is not significant.

Table 4. Cronbach's Alpha for pre- and post-survey by space

<i>Survey</i>	<i>Space</i>	<i>Cronbach's Alpha</i>	<i>Number of items</i>
Pre	Understand	0.756	9
	Synthesize	0.58	3
	Ideate	0.684	4
	Prototype	0.854	3
	Implement	0.766	4
Post	Understand	0.754	9
	Synthesize	0.577	3
	Ideate	0.784	4
	Prototype	0.861	3
	Implement	0.729	4

To figure out the reason behind the lack of reliability of the items associated with the processes of the Synthesize space (items 10-12), we checked Item-Total Statistics. Table 5 shows the corresponding Cronbach's alpha value when each of the items was deleted. Typically, if this value is larger than the original alpha value, the corresponding item should be deleted to increase the overall Cronbach's alpha. However, results showed that the Cronbach's alpha is lower after removing any of the items associated with the processes of the Synthesize space. Therefore, the low reliability of items associated with the processes of the Synthesize space is not because of one specific item, but all items need further adjustments.

Table 5. Item – Total Statistics

<i>Item</i>	<i>Corrected Item-Total Correlation</i>	<i>Cronbach's alpha value when item is deleted</i>
10	0.412	0.434
11	0.366	0.505
12	0.381	0.485

Discussion

The purpose of this research was to describe how a newly established design center at a large Midwestern University developed a survey that can be used to measure the impact of integrating HCD on students' knowledge of performing its processes in existing higher education courses. The survey was developed based on a research-based HCD taxonomy (Lawrence et al., 2021) that outlines the design spaces, the processes, and practices that define what it means for students to implement HCD within the context of a k-12 or higher education setting.

The survey was pilot tested as a pre- and post-survey with 46 students from two courses that integrated HCD in Fall 2019 semester. The overall results from paired sample t-tests indicated a significant improvement in students' knowledge of performing the HCD processes and practices. This suggests that the integration of HCD in the content of these two existing higher education courses was effective at least in providing students with opportunities to practice skills that are essential for developing 21st century mindsets such as collaboration and communication. These mindsets align with what employers of today's workforce seek in their employees. This makes teaching about and through HCD a powerful pedagogical approach that can better prepare higher education students to successfully participate in their future workspaces. Findings from our work add to empirical evidence from other studies that indicates the effectiveness of integrating HCD in higher education courses (Lake et al., 2021; Shehab et al., 2021a, Withell & Haigh, 2013).

In addition, the results indicated low reliability in items associated with the processes of only the Synthesize space. One reason behind low reliability of items associated with the Synthesize space is the poor correlation between the items. We checked the correlation of each test item with the total score test and found that all three items have correlation below 0.45. Therefore, to improve the reliability of items associated with the processes of the Synthesize space, we enriched the content of each item and we increased the number of items from three to seven. Further testing is needed to verify the increase in the reliability in items associated with the processes of the Synthesize space.

The results also indicated a relatively low construct validity. We expect that increasing reliability by changing some items associated with the processes of the Synthesize space will improve the validity of the survey. Nevertheless, one potential reason behind the low validity is that some items of the survey were broad and addressed multiple HCD practices. To address this, we revisited the HCD processes and practices as defined by the HCD taxonomy and broke down some items of the existing survey into items that are associated with specific HCD practices related to the HCD processes per space. Having more specific and targeted items is one direction for improving construct validity in future survey iterations.

Finally, the current survey analysis relied on a small sample size of only 46 responses. This small sample size could have also undermined the validity of the survey. In the future, it is necessary to collect more responses from students to ensure more accurate and stronger survey analysis.

The work presented in this paper is on the assessment of HCD which is a critical dimension that influences the effective implementation of HCD in higher education classrooms (Gómez Puente et al., 2013). Assessing students' learning outcomes as they engage in HCD experiences is a major step towards bringing HCD into K-12 and higher education classrooms (Shehab et al., 2021b). Given that surveys are self-reporting tools that may be subject to students' bias, more research is needed to test other assessment tools that can be used to measure the effectiveness of integrating HCD in existing higher education courses (Melton et al., 2012; Royalty et al., 2019). In addition, more research is needed to develop and test assessment tools that can be used to measure the impact of integrating HCD in existing higher education courses on students' understanding of the underlying disciplinary concepts associated with the course and transfer of knowledge to perform HCD processes and practices to solve other problems in new contexts.

Conclusion

In light of our analysis and suggestions, we revised our survey items. Table 6 shows the items of our revised survey. We are planning to pilot the revised survey in existing courses that integrate HCD in Fall 2021. We are aiming to pilot test the revised survey with a bigger sample size and in other higher education courses that integrate HCD. Using the collected responses, we will run validity and reliability tests to inform our progress towards developing a valid and reliable survey that can measure the impact of integrating HCD in existing higher education courses which, in turn, will promote our efforts of scaling the integration of HCD in existing higher education courses.

Table 6. The revised survey

Space	No	Item	Very Poor (not sure/don't know)	Poor	Fair	Good	Excellent
Understand	1	I know how to develop goals for the project.	1	2	3	4	5
	2	I know how to review the current landscape or context of the project.	1	2	3	4	5
	3	I know how to document my biases, assumptions, and predictions during the project.	1	2	3	4	5
	4	I know how to conduct observations that can inform my understanding of the users' needs.	1	2	3	4	5
	5	I know how to document my observations.	1	2	3	4	5
	6	I know how to run interviews with users.	1	2	3	4	5
	7	I know how to locate resources that are associated with the project.	1	2	3	4	5
	8	I know how to identify extreme users.	1	2	3	4	5
	9	I know how to reflect on my assumptions and biases.	1	2	3	4	5
	10	I know how to reflect on the projects' motivations and stakeholders' needs.	1	2	3	4	5
	11	I know how to filter content for relevance and prioritize information.	1	2	3	4	5
Synthesize	12	I know how to communicate collected data to others during the project.	1	2	3	4	5
	13	I know how to find themes and develop insights.	1	2	3	4	5
	14	I know how to identify design and research opportunities.	1	2	3	4	5
	15	I know how to define the project scope.	1	2	3	4	5
	16	I know how to build on themes and design opportunities to determine what next steps are.	1	2	3	4	5
Ideate	17	I know how to come up with ideas of potential solutions to a problem.	1	2	3	4	5
	18	I know how to communicate proposed ideas of potential solutions to others to get feedback.	1	2	3	4	5
	19	I know how to come up with alternative ideas of potential solutions.	1	2	3	4	5
	20	I know how to identify concepts that are most viable.	1	2	3	4	5
	21	I know how to develop a plan of action that outlines next steps and possible challenges.	1	2	3	4	5
Prototype	22	I know how to create a prototype.	1	2	3	4	5
	23	I know how to communicate a proposed prototype to others to get feedback.	1	2	3	4	5
	24	I know how to evaluate a prototype.	1	2	3	4	5
Implement	25	I know how to revise prototypes to build more sustainable or usable design.	1	2	3	4	5
	26	I know how to develop a plan for executing a final design.	1	2	3	4	5
	27	I know how to plan for, collect, and implement user feedback to ensure successful implementation of a final design.	1	2	3	4	5
	28	I know how to monitor and evaluate social and environmental contexts to ensure the sustainability of the final design.	1	2	3	4	5
	29	I know how to execute functional iterations of a final design.	1	2	3	4	5

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Research on the performance evaluation and preference of design thinking methods in interdisciplinary online course

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Under the COVID-19 epidemic, faced with the problem of ensuring the quality of teaching online, Design Thinking, as a design teaching and evaluation tool for interdisciplinary collaborative courses, has attracted much attention. This research purpose is to explore the learning performance and using preference of four popular design thinking methods in interdisciplinary online courses. This study took an intensive online course for graduate students jointly held by two departments, information engineering and industrial design, as the case study. It developed curriculum based on Brainstorming, Crazy 8, User Journey Mapping and Storyboarding. Quantitative evaluation and Evaluation Grid Method were adopted to compare participants' performance and preference of these four design thinking methods. The results revealed that, compared with Crazy 8, Brainstorming which has the characteristics of open communication and out-of-convention ideas may be the reason why industrial design students are more prominent in Flexibility and Elaboration. By contrast, compared with User Journey Mapping, Storyboarding performed better in Originality and Elaboration than others. This study provides an educational scientific reference of design thinking methods and expects to help educators improve the design curriculum in the future.

Keywords: Interdisciplinary education, Cooperative design, Learning performance assessment, Information engineering, Industrial design

Introduction

The outbreak of the novel coronavirus pneumonia (COVID-19) in 2019 had a huge impact on higher education, forcing traditional offline teaching modes to become unsustainable. Colleges and universities should initiate appropriate measures and enter into the large collaborative online teaching practice in history as quickly as possible, which arise difficulties and challenges for higher education. Since there is as yet no unique online teaching mode for all subjects (Palloff & Pratt, 2013), most teachers face a challenge of their technical and administrative skills in online teaching (Albrahim, 2020). Outcome-Based Education (OBE) emphasizes that the focus of instructional design and implementation goals are on students' internalization and practical application of learning, and that assessment criteria are revised at the right time to accurately capture students' learning status (Bhat, D'Souza, Bhat, Raju & Kumara, 2020). Based on OBE, the main difficulties for higher educators when implementing online collaborative courses arise from the complexity of the learning environment, the difficulty of planning and organizing courses, and the difficulty of assessing teaching and learning, including the selection of online platforms, teaching tools and the planning of their operational processes (Rapanta, Botturi, Goodyear, Guàrdia & Koole, 2020); the establishment of forms of teacher-student interaction (Bervell, Umar & Kamilin, 2020); the organization of online design courses across domains (Iwasa, Hayashi & Ohsawa, 2020); The development of appropriate learning performance evaluation criteria for all the students with different masteries of learning content, access, and breadth and depth of online courses (Hsu & Ching, 2013). Therefore, the corresponding need for an effective and innovative teaching mode to ensure the learning performance of online collaborative teaching is proposed at this stage.

Design thinking is a human-centered problem-solving approach for collaborators on interdisciplinary



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collaboration, team coordination, and solving problems. It supports interdisciplinary members to generate more feasible and sustainable solutions (Arias, Eden, Fischer, Gorman & Scharff, 2000). The double diamond design model, proposed by Design Council in 2004, is considered to be one of the most effective and convincing design thinking process models (Design Council, 2019). This model systematically divides the design process into two diamond (divergence and convergence) stages. In the first divergence stage, the user's needs and contact points can be extensively collected. In the first convergence stage, designers can focus on the key contact points of design requirements and the relationship among each contact point in the process. The second divergence stage is based on the convergence results of the previous stage to develop the design concepts. The second convergence stage is that designers use feedbacks from users and experts to make decisions on the design concepts to obtain the final solution (Przybilla, Klinker, Wiesche & Krcmar, 2018). Currently, in the design course, the commonly used design methods in the divergence phase, including Brainstorming, Empathy Map, Crazy 8, 5W1H and AEIOU etc. The methods in the convergence phase which design courses used mostly, including Point of view (POV), How might we, Persona, User journey mapping and Story Boarding etc. The first divergence and convergence stage is the key to establishing the foundation of a successful concept. Therefore, more attention is paid to train the abilities of the first stage in the design courses. In addition, research on the above-mentioned commonly used design methods are increasing. Among them, we found four methods, Brainstorming, Crazy8, User journey mapping, Storyboarding, are more widely used in the first stage. A number of studies have pointed out that Brainstorming is the most prominent way of producing ideas (Cross, 2000; Paulus & Nijstad, 2003), while startups in Silicon Valley emphasize Crazy8's acuity and efficiency in generating ideas (Levey, 2016). On the other hand, User Journey Mapping can effectively help design student teams to collaborate and reflect on the design process (Sperano, Roberge, Bénech, Trgalova & Andruchow, 2018), while Storyboarding has a better, more understandable and enjoyable experience for novice designers (Truong, Hayes & Abowd, 2006). The professional courses of many fields in higher education involving the conceptual development of prototype design states that prototype activity is a necessary process for the curriculum. Based on the advantages of creativity & innovation, user-centered aspect, participation and problem-solving, more and more higher educators try to apply Design thinking methods to the concept of prototype design in related courses (Abedianpour & Omidvari, 2018; Micheli, Wilner, Bhatti, Mura & Beverland, 2019). Shinohara, Bennett, Wobbrock & Pratt (2017) apply user-centered design methods with design thinking concepts including needs assessment, user interviews, brainstorming, ideating, synthesizing, low-fidelity prototyping, high fidelity prototyping and usability testing in a technology design courses aimed at the students of computer science and information technology. The observed results of the subjects show that students can produce a large number of ideas by conducting Brainstorming before prototyping. Besides, brainstorming also help students master the learning tasks of the course. A design course about the Internet of Trusted Things (IOTT), which researches on the learning quality and relevant experience of Computer Science and Design & Art students, shows that Crazy 8 is an easy and quick method for students from different professions to use. Especially, Crazy8 is useful to converge ideas and determine whether the idea is feasible or not in the design conception stage. The overall qualitative evaluation and student satisfaction of the product prototype are both positive (Gennari & Melonio, 2019). The results of a case study of an undergraduate computer course point out that it is important to apply Crazy 8 which can help students produce better design solutions in the innovation and problem-solving process at the prototype stage (Ferreira & Canedo, 2019). An intervention design course for master students in interaction design, which researches on teaching instructional design tools, states that the use of User Journey Mapping is meaningful for students to realize the sharing of knowledge and practice, collaboration and reflection, and can provide a richer view of the design process in the discipline of instructional design (Sperano, Roberge, Bénech, Trgalova & Andruchow, 2018). A case study of design courses in the fields of software engineering and human-computer interaction proposes that design thinking methods and interactive scenarios, which students use the software system to communicate with all stakeholders and Storyboarding to present their concepts, can help produce more resonant interactive design concepts effectively (Péaire, 2019). A study of higher education courses by Lu & Hsiao (2019) believes that the Evaluation Grid Method (EGM) has advantages of deeply uncovering the attractive factors of the products required by users. In a course, EGM can objectively and effectively help educators capture students' preference of using design tools. Most studies describe the effectiveness of the above design thinking methods, but there are few studies describing the learning effectiveness and students' preference aiming at research courses. Therefore, in order to better understand the applicability of these four design thinking methods in the current complex interdisciplinary collaborative online courses, this study takes a graduate interdisciplinary online course as a case study to compare Brainstorming with Crazy 8 and User Journey Mapping with Storyboarding, which are applied to verify the learning effectiveness of the students in the course, and conduct the EGM to explore the

students' preference factors of design thinking methods. It is expected that this study helps higher educators improve curriculum design and evaluation of learning outcomes.

Theoretical background

Design thinking Methods

Design thinking, proposed by IDEO, emphasize human-centric innovative method of problem-solving, which take human needs and behaviors into account, as well as technological and commercial viability which is emphasized in the past. It has a unified problem-solving strategy and can help designers solve complex design problems (Brown & Katz, 2011; Liedtka, 2015).

Brainstorming, proposed by Alex Osborn in 1938, is a method to stimulate creativity and strengthen thinking. It is one of the main methods in interdisciplinary creative teams (Osborn, 1957; Dennis & Williams, 2003; Ivanov & Zelchenko, 2019). The basic rules are to pursue quantity of ideas, to prohibit criticism, to promote unique and creative ideas, and to synthesize and improve ideas. It can be done by one person or a group of people, and the participants will sort out all the ideas that follow the basic principles. During the whole process, the opinions and insights from everyone must not be criticized. It's better to generate as more ideas and problem-solving methods as possible.

Crazy 8 is a kind of design sprint method, proposed by Google Ventures, requiring each person to come up with 8 solutions to a problem in 8 minutes. It is a challenging but quick way to draw rough sketch which is popular among design companies. It does not require a complete solution, so as to avoid influencing each other's ideas and to promote independent thinking. When Crazy 8 being implemented, the ideas are presented in simple drawings or written solutions (Jones, Nabil, & Girouard, 2021; Knapp, Zeratsky, & Kowitz, 2016).

User Journey Mapping was first introduced in service design by IDEO. Subsequently, it became one of the most widely used design thinking methods. It can help design teams to better understand each stage of the customer's use of the service process, including the touch points of the entire process before using, during using and after using in a process. It also visualize the experience of stakeholders interacting with a product or service to enhance design impact and elevate it to a strategic level (Brown & Katz, 2011). Following are the five steps:

1. Use the stakeholder map to identify core stakeholders and other stakeholders
2. After a discussion, divide the experience into different stages
3. The touch points corresponding to each stage, includes stakeholders, environment, systems, and items
4. Collect the behaviors, thoughts and feelings of stakeholders according to the description of the touch points at each stage
5. Combine the above-mentioned information to describe the relationship between interest and emotional ups and downs at each stage

Storyboarding was first used in the field of developing movies, Television clips and animations, and was later introduced into the development stage of the design field (Hart, 2013; Truong, Hayes, & Abowd, 2006). It is a method of visualizing story content that allows design teams to predict the problems, motivations and experience that users may encounter in the expected situation. The final presentation can provide visual demonstration for users, allowing the design teams to build the contact points of multiple modals based on empathy for users in the convergence stage, and achieve a rich description of the contextual environment (Rasool, Molka-Danielsen, & Smith, 2020; Shi, Cao, Ma, Chen & Liu, 2020). Following are the five steps:

1. Set characters, scenes and plots, which the story content can describe the interaction between the product and the expected users. Next, connect the entire story script in the way of people, events, time, place, and things. Final, set the overall story with characters and scenes and the possible plot.
2. Draw a simple plot according to the set story environment, try to avoid unnecessary plots through easy-to-understand sketches and tell others the story you want to tell clearly.
3. Add your script to add emotion to the plot. In the storyboard, the character should be the center, so it needs to reflect the character's current thoughts and emotions. The plot which is given emotion makes readers get emotional resonance.
4. Draw the basic line draft of the overall story, transform each step into a picture, and show what happens at each moment and the current thoughts of the characters in the picture.
5. Design clear outcome. When the composition of the storyboard is completed, the steps of the

story will be obtained to discover the problems that users will encounter, so that we can better understand our users which the design team can share this knowledge. You can make more subtle adjustments to the content to make the plot flow more in line with the user's thoughts.

Evaluation Method

The Evaluation Grid Method (EGM) was proposed by Sanui, which was improved based on the Repertory Grid Method (RGM), proposed by Kelly (Kelly, 1955; Sanui, 1996). EGM gains insights from the cognitive aspects of subjects' perception of a specific thing in depth. It can accurately extract attractive factors from the thing based on individual thought. In the implementation, participants compare the target objects A with B through personal interviews. Next, participants clearly discuss the similarities or differences between them, and acquire three levels of evaluation items of their strengths or weaknesses, i.e., the abstract concepts which are defined as upper level, original evaluation item characteristics (factor) which is middle level and the specific constituent elements or conditions which is lower level. Finally, draw the evaluation structure chart, so as to vague and implicit user emotional preferences to quantify and filter out the key charming factors.

Research Process

The process of this study is divided into two phases. In the first phase, after confirming the online platform, Brainstorming and Crazy 8 were applied to generate and develop the ideas of users' needs; User Journey Mapping and Storyboarding were used to develop the concepts on user experience. The second phase was the evaluation phase, in which the experts conducted an assessment of the learning performance of the four design thinking methods, and the interviewees used the EGM to conduct two comparisons of the two groups of methods which uncovered users' needs and developed concepts on user experience. In consequence, the combined analyses of results were examined to understand the applicability of the design thinking methods and the students' preference for the application of the methods in the course.

Case study and Results

Experiment Phase

The case study was an online course for graduate students which jointly organized by National Cheng Kung University (Taiwan) and the Nara Institute of Science and Technology (Japan), with a two-day intensive course on Sustainable Development Goals (SDGs) in December 2020. This course included 3 times in six weeks and the interval between classes was two weeks. Each instruction class was 5 hours and the rest time of a day was the discussion time for each group. The spoken language of course was English. A total of 40 participants, including 7 doctoral students and 33 master students, were divided into 10 groups including 4 students in each group. All of students are from two disciplines, information engineering and industrial design. The course chose two online platforms, Remo and Miro, for online teaching and team discussion. Remo is used for the instructor to assign tasks and observe and communicate with groups, and Miro is used for students to practice design thinking methods and demonstrate their learning performance.

In the first class, participants prepared for the group icebreaking activity based on the course theme and the instructors introduced how to operate four Design thinking methods. In view of expecting all the course participants benefiting from learning four design thinking Method as the course goal, the results and analysis of this research did not form a control group (all process of the tasks is not guided by the instructors).

In the second class, based on the SDGs, participants carried out an exploration of producing ideas of users' needs, Brainstorming and Crazy 8 methodologies were implemented with different tasks. The task of the former was to develop and converge the design requirements for users based on the topic. Each group of students developed positive and negative design requirements (15 minutes) and then shared and discussed with all the course participants to select the best design requirements (30 minutes); the task of the latter was to develop and converge the specific product requirements for the proposed design direction. Each group of students conducted two rounds of crazy 8 questions (8 minutes each), and then shared and discussed with all the course participants to filter out the best product requirements (30 minutes). The rest of the course time was spent on the preparation and production of the team's outputs.

In the third class, participants devoted themselves to developing concepts of user experience based on the same topic. There were different implementation tasks in User Journey Mapping and Storyboarding. The task of the former was based on empathy to diverge and converge the touch points of the product using process. Each group of students conceived the touch points (30 minutes) and then shared and discussed with all the course participants to identify the touch points of the product using process (30 minutes); the latter task was

to conceptualize and visualize the touch points of user-product interaction circumstances. Each group visualized the interaction circumstances (30 minutes) and then shared and discussed with all the course participants to identify the touch points in the product interaction context (30 minutes). Each group's outcome was presented based on the standardized criteria of the four design thinking methods. The rest of the course time was spent on the preparation and production of the team's outcomes.

Brainstorming round 1						Brainstorming round 2						Brainstorming conclusions			
Immediate Healthcare for Newborn Babies in the Least Developing Countries (LDCs)						Delayed Healthcare for Newborn Babies in the Least Developing Countries (LDCs)						1. Address the concern of shortage of expert doctors 2. Build AI application to diagnose health risks of newborn babies 3. Spread awareness and educate local healthcare workers about the essential newborn care 4. Low cost incubators with improved functionalities 5. VR contents to provide information about healthcare practices of babies			
Group member A	Low-cost devices to improve the existing infrastructure at hospitals	Record the APGAR scores of the newborn babies through an app	An application to analyze APGAR scores and diagnose health conditions of newborn babies	Spread awareness about essential newborn care practices	Awareness of the hygiene around the newborn baby to avoid infections	Send APGAR data to the expert doctors for verification	Group member A	Lack of awareness about essential newborn care	Expensive incubators	Poor healthcare infrastructures	Shortage of expert doctors			Emergency assistance cannot be timely provided.	Unhygienic hospitals
Group member B	Detect baby's problem using the camera.	Make a mask that protects babies from toxic gases.	Put the sensor in the Diapers to detect the baby's health.	Make an incubator that reproduces the feeling of being held by the mother	Sending micro changes in the baby's facial expressions and sleeping in AI.	The Japanese picture books called as "Thou" to make the babies happy	Group member B	High medical cost	Lack of medical equipment	Low dietary nutrition	Can't notice baby's illness			Too much work for parents	Polluted air
Group member C	A robot to provide milk to the newborn babies all the time	A heat blanket to detect the newborn baby's movements and heartbeats	A VR Video to provide information about how to take care of baby	A low-cost incubator to provide skin touch	An app to teach mothers about health care practices of the newborn babies	An Air filter inside the low-cost incubator	Group member C	bad air quality	Cold environment at night	Mother can't feed their babies	Mother can't take care of babies because of busy housework			shortage of hospital	incubator didn't have skin touch functionality
Group member D	A device on newborn's clothes to detect body temperature	Add equipment to detect changes in newborn baby's heart rate	Detect the temperature of milk from baby's bottles.	Materials that change color when heated to understand the temperature inside the bottle	Abdominal massage equipment to promote baby's food digestion	When a baby's emergency is detected, access the medical emergency device	Group member D	Not sure about the temperature of milk	Baby clothes limit the range of activities	Poor air environment	The clothes are not warm enough			Unknown emergency causes of infant crying	The mouth of the baby bottle is too big
Crazy 8 round 1						Crazy 8 round 2						Crazy 8 conclusions			
Group member A			Group member B			Group member A			Group member B			Low cost incubator with improved functionalities:  Idea 1  Idea 2			
Low cost incubators			App to train healthcare workers about essential newborn care			Centralized system to keep track of high risk babies			Low-cost incubators					VR HMD (monitor) for babies. They can meet mother every time.	
App to record Apgar test score of babies			App to connect volunteers who can assist healthcare workers			Predict vulnerabilities from the Apgar test scores using AI			App to connect volunteers who can assist healthcare workers and mothers					Toys that promote the psychological health of babies.	
App to provide hygiene knowledge about babies			App to detect temperature, noise level, air pressure around babies			Low cost medical supplies required for infants			App based on guiding newborn care and hygiene knowledge					Smart watch sensing babies health.	
Low cost medical supplies required for infants			Low-cost robot to keep track of baby's health progress/movements			App which can record Apgar test scores and get it verified by the doctors			App to exchange knowledge about infant nutrition and health					Reusable incubator	
Group member C			Group member D			Group member C			Group member D						
			Baby bottle with water quality test function			Air filter on the incubator which can make the baby breathe safely			The smart incubator which can create skin touch and info of babies			Massager that helps babies digest food			
			Device for real-time detection of baby's body temperature and heart rate function			Incubator can use UV do sterilization every hour			incubator can provide milk			Precise quantitative medicine conditioning equipment combined with milk bottles			
			Device for detecting baby's bloating			Baby sleeping bag with heat preservation and ventilation function						A device to determine the cause of the baby's crying through the baby's movement and crying			

Figure 1. The outcome of Brainstorming and Crazy 8

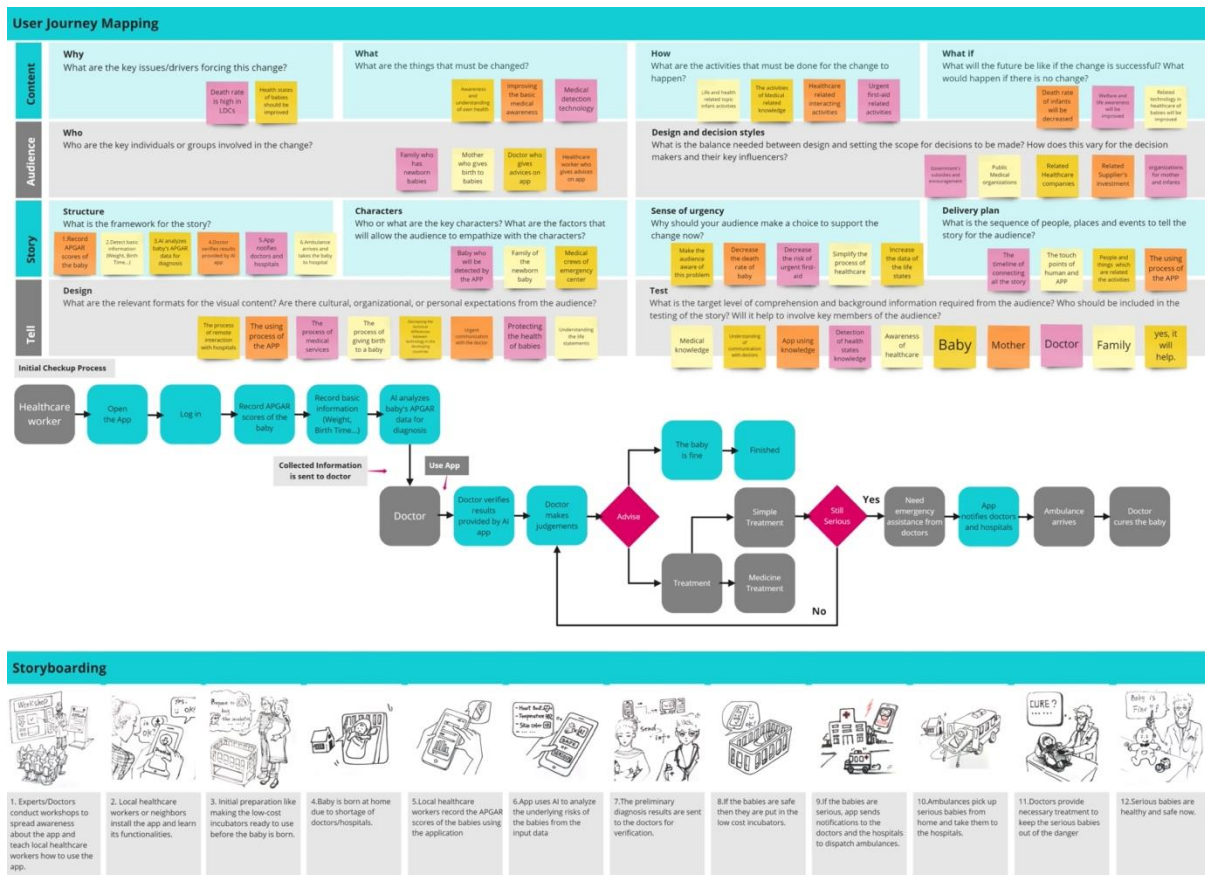


Figure 2. The outcome of User Journey Mapping and Storyboarding

Take one of the groups in this course as an example. This group addressed the problem of high neonatal mortality around the Least Developing Countries (LDCs). So, they sought the solutions to provide immediate healthcare for newborn babies in LDCs. Figure 1 shows the outcomes of their design diverging ideas and converging design goals based on Brainstorming and the outcomes of design concepts and two converging directions for continued development by using Crazy 8. Figure 2 shows the outcomes of User Journey Mapping and storyboarding which are applied to find out more accurate user experience and to develop the user scenario.

The Assessment of Course Outcome

The Torrance Tests of Creative Thinking are based on four scales of creativity, Fluency, Flexibility, Originality and Elaboration. This study assessed all the group performances on a 5-point Likert scale. Fluency refers to the number of ideas, Flexibility refers to the diversity of ideas, Originality refers to the rarity of ideas, and Elaboration refers to the completeness and precision of the presentation of ideas. Since the course results of one group were not well-recorded, the results of nine groups were evaluated. Two teachers from Information Engineering and Industrial Design majors rated the performances of four design thinking methods (Brainstorming, Crazy 8, User Journey Mapping, and Storyboarding) of each group. After it, we used descriptive statistics and paired sample t-test to check the learning performance of the four design thinking methods which were divided into two kinds. The results are shown in Table 1 and Table 2.

Table 1. Descriptive Statistics related to learning performance

		M	N	Std. Deviation	Std. Error		M	N	Std. Deviation	Std. Error
Total	B	3.972	9	.599	.200	S	3.889	9	.636	.212
	C	3.583	9	.515	.172	U	3.194	9	.702	.234
Fluency	B	4.333	9	.791	.264	S	3.944	9	.768	.256
	C	4.111	9	.741	.247	U	3.444	9	.846	.282
Flexibility	B	3.833	9	.750	.250	S	3.667	9	.707	.236
	C	3.222	9	.712	.237	U	3.167	9	.661	.220
Originality	B	3.611	9	.741	.247	S	3.889	9	.651	.217
	C	3.389	9	.821	.274	U	3.000	9	.707	.236
Elaboration	B	4.278	9	.507	.169	S	4.056	9	.846	.282
	C	3.611	9	.546	.182	C	3.167	9	.791	.264

B - Brainstorming, C – Crazy 8, S - Storyboarding, U - User Journey Mapping

Table 1 shows that, among the nine groups of students, Brainstorming is the highest overall learning performance of the four design thinking methods, and User Journey Mapping is the lowest. Among the four creativity scales, Storyboarding puts in the highest learning performance at Originality. Brainstorming puts in the learning performance at the other three creative scales. However, User Journey Mapping has the lowest learning performance in the four creativity scales.

Table 2. Paired t-test Statistics related to learning performance

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		t	df	Sig
B - C	Total	.389	.211	.071	.226	.551	5.518	8	.001
	Fluency	.222	1.034	.345	-.573	1.017	.645	8	.537
	Flexibility	.611	.601	.200	.149	1.073	3.051	8	.016
	Originality	.222	.667	.222	-.290	.735	1.000	8	.347
	Elaboration	.667	.250	.083	.475	.859	8.000	8	.000
S - U	Total	.694	.235	.078	.514	.875	8.874	8	.000
	Fluency	.500	.500	.167	.116	.884	3.000	8	.017
	Flexibility	.500	.433	.144	.167	.833	3.464	8	.009
	Originality	.889	.547	.182	.469	1.309	4.880	8	.001
	Elaboration	.889	.333	.111	.633	1.145	8.000	8	.000

B - Brainstorming, C - Crazy8, S - Storyboarding, U - User Journey Mapping

According to the results in Table 2, the critical value table of t-test shows that $t=0.05(9-1)=1.860$. In the comparison of the total scores of Brainstorming and Crazy8 in the four creativity scales, the value of $t=5.518>1.860$, which means that the participants in nine groups had significantly higher learning outcomes in Brainstorming than Crazy 8. The value of $t=3.051>1.860$ for Flexibility and $t=8.000>1.860$ for Elaboration indicating that the performance for both of these measures of Brainstorming was better than Crazy 8. In the comparison of the total scores of User Journey Mapping and Storyboarding in the four creativity scales, the value of $t=8.874>1.860$, showing that Storyboarding was more prominent than User Journey Mapping for student learning in this course. The t-values of both methods for the four creativity scales were significantly greater than the critical value, indicating that Storyboarding provides better performance than User Journey Mapping based on four creativity scales.

The Assessment of Using Preference

In the preliminary interviews of students' preferences with participants, all students recognized that the course experience based on the four Design Thinking methods was satisfied and some students expressed their fondness for a certain design thinking method. In order to further understand students' preferences in using all the four design thinking methods, 12 participants (6 students from industrial design and 6 students from information engineering majors) were recruited from the course participants who had clear preferences in the method and interviewed by adopting EGM. According to the results of the EGM interviews, among the four design thinking methods, 7 interviewees preferred Brainstorming (5 from industrial design and 2 from information engineering), 5 interviewees preferred Crazy 8 (1 from industrial design and 4 from information engineering). On the other hand, 12 interviewees preferred Storyboarding compared to User Journey Mapping. Therefore, we conducted EGM interviews with the 3 most popular methods of interviewees. The evaluation structure chart is shown in Figure 3, Figure 4 and Figure 5.

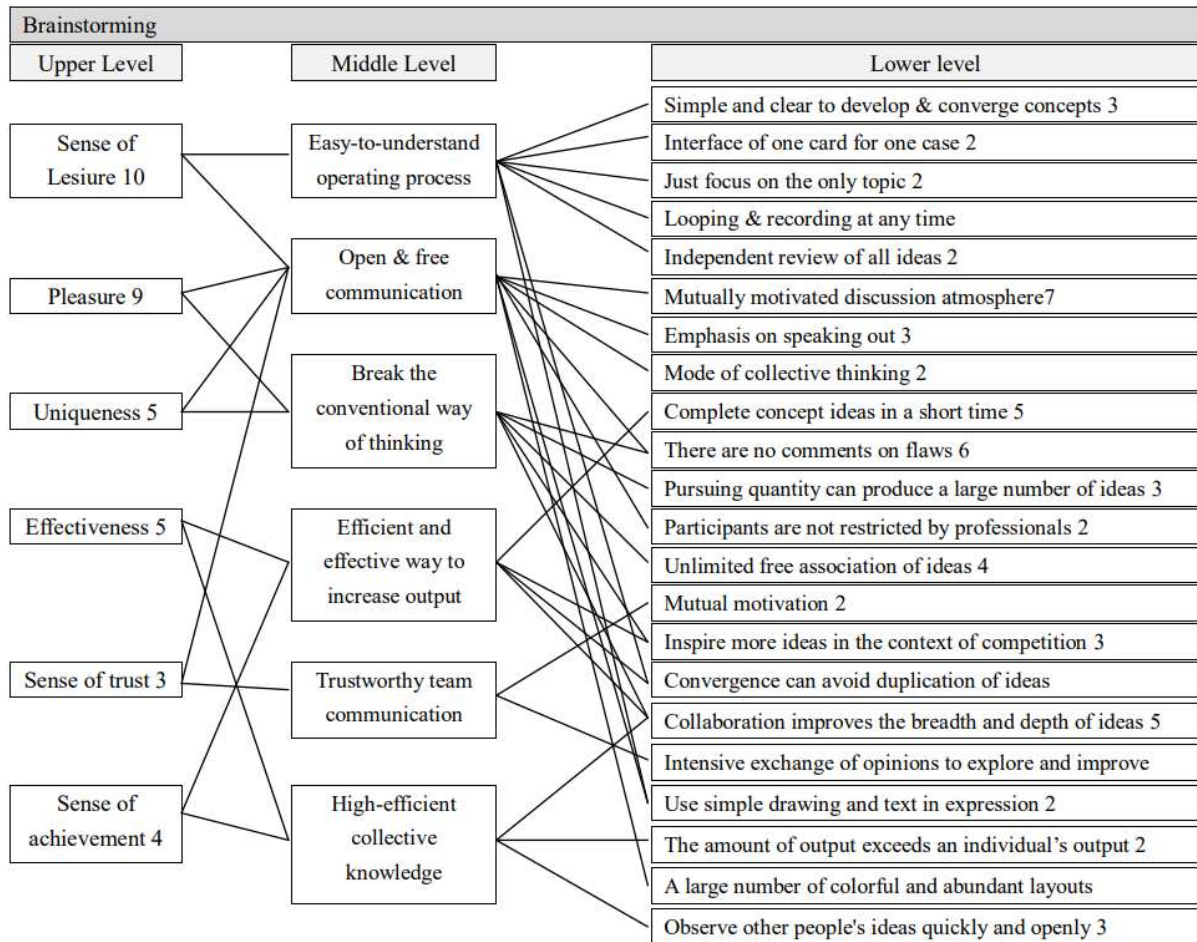


Figure 3. Evaluation structure chart of Brainstorming

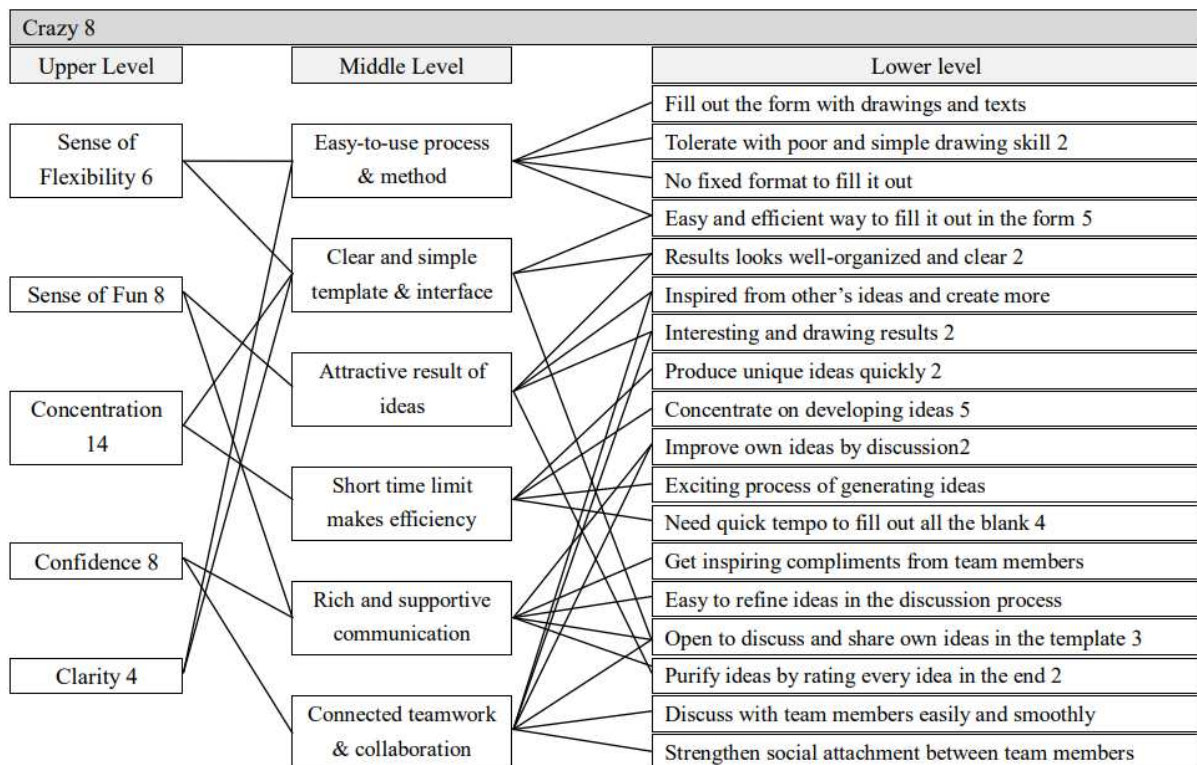


Figure 4. Evaluation structure chart of Crazy 8

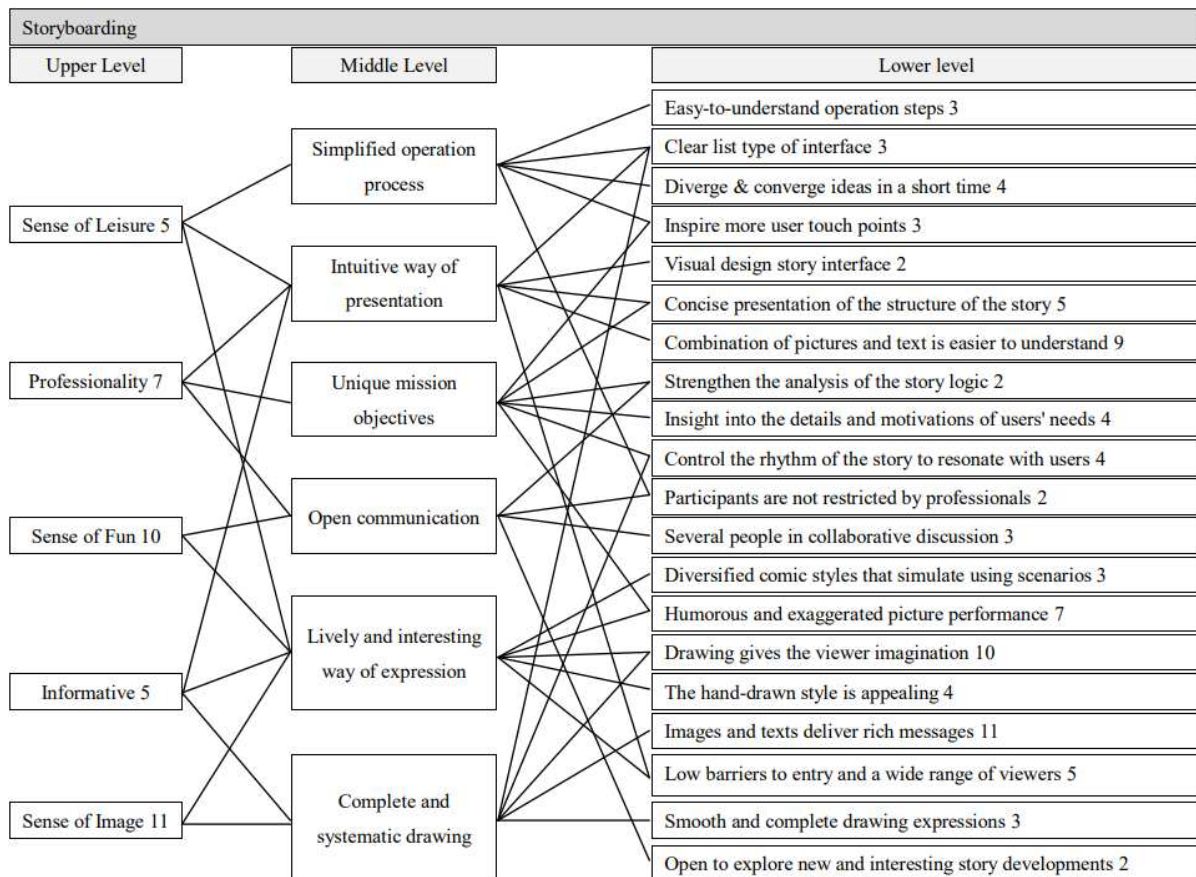


Figure 5. Evaluation structure chart of Storyboarding

Interviewees proposed different preference factors, and the number of times of each mentioned factor varied. During the Brainstorming interviews, 'Sense of Leisure' and 'Pleasure' were the most mentioned words by the interviewees, and the least mentioned word by the interviewees was 'Sense of trust'. According to the Miryoku engineering perspective, 'Sense of Leisure' is the main factor affecting students' perceptual evaluation, while 'Sense of trust' is the least significant. In addition, according to the analysis of the construct elements corresponding to each perceptual evaluation factor, Brainstorming can be concluded that seven interviewees thought that 'Mutually motivated discussion atmosphere', 'There are no comments on flaws', 'Unlimited free association of ideas' which had the characteristics of 'Open & free communication' and 'Break the conventional way of thinking' brought them 'Sense of Leisure' and 'Pleasure'. From the interview results of Crazy 8, it was found that 'Concentration' which was mentioned most frequently by the interviewees, was the main factor affecting participants' perceptions. While 'Clarity' which was mentioned the least (4 times) was the least significant. Five interviewees thought Crazy 8 was 'Easy and efficient way to fill it out in the form', 'Concentrate on developing ideas', 'Need quick tempo to fill out all the blank' which had the characteristics of 'Clear and simple template & interface' and 'Short time limit makes efficiency' could make them more 'Concentrate'. From the interview results of the storyboarding, it was found that 'Sense of Image' and 'Professionalism', which were mentioned most frequently, were the main factors affecting students' perceptual evaluation, while 'Informative', which was mentioned least, was the least obvious. Most interviewees believed that Storyboarding had 'Humorous and exaggerated picture performance', 'Combination of pictures and text is easier to understand', 'Drawing gives the viewer imagination' and 'Images and texts deliver rich messages', which can be corresponded to characteristics, 'Lively and interesting way of expression' and 'Intuitive way of presentation', so that bring them 'Sense of Image' and 'Sense of Fun' prominently.

Conclusion

Driven by the current global demand for online education, this study found ways to support higher educators to improve teaching curriculum implementation and ensure teaching quality in the complex education circumstances. This study examined the quantitative learning outcomes and qualitative using preferences of four design thinking methods through a graduate interdisciplinary online course.

The results of this study show that the learning performance of the course is higher when using Brainstorming

and Storyboarding. The quantitative results show that students learn better with Brainstorming than Crazy8, which enables students to have more diverse and flexible ideas, and more detailed ideas. The results of the qualitative analysis show that, between the Brainstorming and Crazy 8, Brainstorming is more popular among industrial design students. They think that Brainstorming can help them to think and discuss without restrictions and openly. The main reason is that industrial design students have the personality of openness to experience, which have a significant correlation with the quantity of ideas and quality of the output (Bolin & Neuman, 2006). In addition, Urban & Jellen (1996) also believes that, in the design and creation, the personality of openness to experience and creativity are the most relevant among all the big five personality. Crazy 8 is more preferable for students majoring in information engineering. They believe that Crazy 8 has strict time pressure that can make people be concentrate, help improve efficiency, and make design ideas more focused. The main reason may be that students majoring in information engineering are better at systematic thinking which closely related to their professionalism. On the contrary, Design thinking methods that do not meet their professional characteristics will bring them more difficulty to learn (Dym, Agogino, Eris, Frey & Leifer, 2005). Integrated quantitative and qualitative analyses show that, compared with Crazy 8, industrial design students thought the characteristics of open communication and out-of-convention ideas can explain the reason why the Flexibility and Elaboration in the use of Brainstorming was more prominent. The quantitative results of User Journey Mapping and Storyboarding found that Storyboarding's overall learning outcomes and its learning outcomes on the four creativity scales (Fluency, Flexibility, Originality and Elaboration) are superior, they believed that Storyboarding increased the number of ideas and improved the creative quality of the ideas. The interview results revealed that Storyboarding was also favored by the majority of students, while User Journey Mapping was not significantly preferred by the students, mainly because the interesting and vivid presentation of Storyboarding was easier to convey the relevant messages they wanted to express. Integrated quantitative and qualitative analyses show that, compared with User Journey Mapping, all groups thought that Originality and Elaboration were more prominent than other two creativity scales in use of Storyboarding.

The research results show that it is feasible and effective to use design thinking methods in the course design and course assessment of Graduate Interdisciplinary Online Course. This study suggests that implementing Brainstorming and Storyboarding can improve students' learning performance in similar courses. In design developing stage, Brainstorming is more suitable for students of industrial design, Crazy8 is more preferred by students of information engineering, and Storyboarding is more suitable for the students in these two majors. Because the study is based on the experimental results of a practical course, there might be limitations of the unstable online communication platform, small sample size in the implementation of the course, and the familiarity difference and understanding levels of four design methods between two departments. In the future work, it would be further explored on the learning performance of students' learning in similar courses using design thinking methods on different online communication platforms and increasing the sample size or setting more strict principles on sampling participants to obtain more valuable findings. The research results of this study can provide a kind of solution which using design thinking methods as the design teaching tools in graduate interdisciplinary online course.

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I Can and I Will

A Study of 'Grit' in a Collaborative Team Learning Studio Pedagogical Culture

Zhengping Liow

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Despite its long history, architecture education remains under-theorised. Design educators' faith in the ubiquitous Master and Apprentice (M&A) pedagogy is increasingly worrying where knowledge is tacitly transferred in asymmetrical power structured environments through the 'Hidden Curriculum'. Some students thrived. While some did not. Were some learners grittier than others? Grit (passion and perseverance for long-term goals) was often used as predictors of academic success. The experimental heterarchical Collaborative Team Learning (CTL) studio pedagogical culture departs from the 'Mystery-as-Mastery' authoritarian one-on-one (OOO) pedagogy, characterised by the tutor-induced cross-pollinative peer-to-peer formative reviews in normalising daily 'setbacks' relating to their individual projects. The three-year longitudinal research explored possibilities of inculcating Grit capitalised on their first-year's CTL architecture studio experience. Inferential statistics revealed that both CTL and OOO learners failed to register positive growth in their Grit despite CTL's significant outperformance during their first year. This is a timely study of exploiting design education's ambiguous and iterative nature in investigating the viability of instilling learners' Grit in preparation for an increasingly uncertain future.

Keywords: Non-hierarchical Studio Pedagogical Culture; Collaboration; Grit; Hidden Curriculum; Student Engagement

Introduction

The most dangerous phrase in our language is 'we've always done it this way.' – Grace Hopper

Despite its long history and significance in design education, the concept of the Design Studio remains elusive, with no single definition that accurately describes it (Schön, 1987). Cultural and dialogical pedagogic activities (Schön, 1984; Biggs, 1999) are embedded in a socialised learning environment (Crowther, 2013; Owenly, 2013) that deepen students' understanding of design that often led to the enculturation of students into the 'desired' behaviours of the profession (Crowther, 2013; Dutton, 1987; Stevens, 1998; Webster, 2005; Wilson, 1996) through the Hidden Curriculum. The creative design process is often structured by ambiguities and uncertainties (Orr & Shreeve, 2017; Tracey & Hutchinson, 2016) that warrants differentiated contents and studio teaching methods amongst different institutions (Ledewitz, 1985). Nonetheless, the authoritarian Master & Apprentice (M&A) One-on-One (OOO) studio pedagogical culture remains deeply pervasive (Goldschmidt, 2002; Goldschmidt, Hochman & Dafni, 2010; Liow, 2016; Mewburn, 2009; Tonkinwise, 2011; Webster, 2004; Webster, 2005) through the decades.

The Studio Culture often referred to daily 'experiences, habits, and patterns found in the design studio' (Koch, Schwennsen, Dutton & Smith, 2002), which is substantially influenced by tutors' teaching methods (Ersine Masatlioğlu & Parker, 2017). Design tutors hired straight from the profession with limited pedagogical training bring along value systems that reinforce the black-boxed "Mystery-as-Mastery" teaching practices (Argyris & Schön, 1974; Banham, 1990). Tutors are purported to be hesitant to demystify the design process as to maintain asymmetrical M&A power relations heavily dependent on implicit knowledge transfer. Tacit knowledge, which manifests itself as the Hidden Curriculum, is often predicated on tutors' debatable aesthetic



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preferences, intuitions, spatial perceptions, problem-solving techniques (Venkatesh & Ma, 2019), motivational and ethical values of the profession/discipline (Dutton, 1987). The responsibilities of absorbing tacit knowledge are pushed over to the unsuspecting learners, further aggravating students' anxiety with design education's Pedagogy of Uncertainties/Ambiguities. Failure to adhere to the tutor's directed instructions (often late in the design process) or difficulties in keeping up with unrealistic expectations has increasingly left earnest learners struggling with mental health issues. The prolongation of late nights, anxieties and depression (AIAS, 2008; Kirkpatrick, 2018; Leon, Linova, Squires, & Daros, 2014; RIBA, 2017; RIBA, 2018) are often perpetuated in the oppressive OOO M&A studio learning environment.

A handful of students strangely thrived under oppressive conditions while the vast majority do not (Kirkpatrick, 2018). The survivors were deemed to have successfully encultured/socialised into the system by learning the rules of the game (Webster, 2005). Most students endured by keeping to their guns at the expense of their mental health. Were some students grittier than others? Grit is a malleable construct (Bashant, 2014; Fitzgerald, 2016; Weisskirch, 2018) defined as 'passion and passion for long-term goals' (Duckworth, Peterson, Matthews, & Kelly, 2007). In the context of this study, Grit extends beyond students coping well with the presence of stressors to the ability to 'recover and excel' from the daily 'design setbacks' experienced in their design projects. Grit was often validated as a reliable predictor of academic performances and retention (Duckworth et al., 2007; Duckworth & Quinn, 2009) and corresponded with high frequencies of 'Deliberate Practice' (Duckworth, Kirby, Tsukayama, Berstein, & Ericsson, 2011). Deliberate Practice focuses on activities with specific goals of improving performance and working on resolutions targeting specific weaknesses (Ericsson, 2004). Although the construct of Grit has been extensively researched, limited attention was received in design/creative education (Rojas, 2015).

This longitudinal study examines whether Grit can be spontaneously inculcated as a 'by-product' of the iterative design process and driven by the hypothesis that the alternative non-hierarchical Collaborate Team Learning (CTL) studio pedagogical culture as a catalyst for inculcating Grit. As opposed to the authoritarian OOO M&A mode of engagement, the CTL pedagogy is fuelled by the tutor-induced Peer-to-Peer (P2P) cross-pollinative reviews in a bid to normalise the daily 'design setbacks' in a first-year architecture design studio. Moreover, it has been advocated that collaborative learning is a viable way to increase students' grittiness (Chang, 2014). The design pedagogy of students' repetitive and laborious efforts of design refinement shared a similar mechanism with Ericsson's (2004) 'Deliberate Practice', often setting up informal peer support systems akin to Wenger's (1999) Communities of Practices within the socialised design studio.

Inferential statistics are carried out in investigating possible relationships between these variables. This paper examines the possibilities of building Grit to be validated alongside CTL's academic outperformance over their OOO peers. Strangely, associations between grittiness and academic scores are revealed to be weak with a downward trend. On a brighter note, CTL students are reported to have outperformed their OOO peers for their first year of study. After CTL learners formally transit into an OOO pedagogy in their subsequent years, the differences between their academic scores between both groups are registered to be insignificant. This finding suggests that CTL's dismantling of the OOO M&A studios' asymmetrical power structures can yield positive academic outcomes only when their tutor was actively facilitating. Questions on CTL studio pedagogical culture's efficacies in instilling the non-cognitive trait of Grit over an extensive period remains inconclusive.

Bridging the transition of first-year students growing up with closed-ended curricula to learning design through an ambiguous design process is critical, as their first-year performance has shown to be a reliable predictor of their ongoing academic success (Crowther & Briant, 2020). This research contributes to the scholarship of teaching and learning in design education by broadening our perspectives towards an alternative non-hierarchical team-based design pedagogy relevant for an increasingly collaborative future.

Faithfulness to the Master and Apprentice Studio Pedagogical Culture

Design Studio's centrality in design education remained undisputed amongst educators. However, the importance of a sound pedagogical process is often neglected as studios are increasingly obsessed with design outcomes (Till, 2003). The authoritarian OOO M&A model inherited from the Beaux-Arts continues to perpetuate in studios today (Crowther, 2013; Goldschmidt et al., 2010; Liow, 2016) where tutors unconsciously oppress and demotivate students, negatively impacting their performance (Austerlitz et al., 2008). Studio pedagogy is often tutor-centric, contrary to popular beliefs of it being a student-centred learning model. While design tutors play critical roles in influencing the learning environment, teaching practises are often relegated to intuitions by reproducing their own learning experiences (Grasha, 1996; Goldschmidt, Casakin, Avidan & Ronen, 2014; Rapoport, 1984; Moore, 2001).

Design Education's Pedagogies of Uncertainties/Ambiguities (Crowther, 2013; Orr & Shreeve, 2017; Temple, 2018; Tovey, 2018) have unwittingly endorsed Argyris and Schön's (1974)'s (1974) M&A's 'Mystery-as-Mastery' tacit teaching model comparable with Olson & Bruner's (1996) notion of 'Folk Pedagogy'. 'Folk Pedagogies' are situated within an intuitive realm where teachers rely on implicit theories, one-way dialogues where interpretation is restrictive and relies heavily on mimicry as a pedagogical strategy (Olson et al., 1996). The M&A's authoritarian dialogical exchanges instil non-cognitive dispositions, value systems, aesthetical tastes, and beliefs (Dutton, 1991) in adherence to professional practices' exploitative and oppressive behaviours into the minds/behaviours of learners. These value systems are enculturated through the 'Hidden Curriculum' in the design studio.

The Hidden Curriculum and the [Enculturated] Studio Pedagogical Culture

The Hidden Curriculum that lurks beneath the visible structures of design studios is seldom discoursed (Webster, 2008), especially its immediate impact on the studio pedagogical culture (Ersine Masatlioğlu & Parker, 2017). The socialised learning environment cannot be rationalised as neutral grounds for knowledge transmission (Jackson, 1968) with underlying implicit sets of influences operating within organisational structures and cultures (Hafferty, 1998). The M&A's OOO pedagogical modus operandi of the tacit Hidden Curriculum remained profoundly pervasive, espousing the tutor-centred 'Mystery-as-Mastery' phenomenon (Argyris & Schön, 1974) of exerting their power and imaginative expressions on learners. The attitudes and value systems perpetrated by the M&A's Hidden Curriculum causes immense stress, leaving students being neglected and suppressed (AIAS, 2020). Students' negative experiences, excessive strains and confusion with the iterative process often attributes to the hierarchical M&A implicit teaching methods with high workload expectations.

The lack of student agencies, wearing badges of honour of glorifying sleep inadequacies, being confined to limited creative expressions (AIAS, 2020) are daily anecdotes in the studio. Learners' discretion to exercise their design decisions after experiencing 'design setbacks' is rarely evident, as they are 'highly encouraged' to stick to their tutor's solutions for fear of jeopardising their grades (Liow, 2021). Design competencies are superficially developed through mimicry rather than broadening students' exposure and confidence in their design process. Such teaching methods are detrimental to beginning designers' education in finding their feet after setbacks and their identity through the self-discovery/reflective design process. Learners' mental wellbeing consequently takes a toll. Students' motivation for burning through late nights is fuelled by peer pressure and anxieties of being publicly humiliated in design reviews (Webster, 2005). With negative behaviours/mindsets instilled by fear and insecurities, the viral and toxic 'cultural' habits, indoctrinated through observing and enacting (Dutton, 1997) senior students' working patterns, are astonishingly advocated by their tutors (Austerlitz et al., 2008)!

Design and Medical pedagogies are similar in their investigative and evaluative methods examining learners' proposed 'contextualised' strategies during reviews. Remarkably, one crucial trajectory prevalent in medical pedagogy research is to make these Hidden Curricula explicit. Mackin, Baptiste, Niec & Kam (2019) revealed that medical professionals' lived experiences with the Hidden Curriculum often resulted in undesirable repercussions. Medical apprentices reported emotions of vulnerability, hierarchy, privilege and dehumanised, while positive traits such as navigation, negotiation and positivity were weakly echoed. These findings were comparable to the sentiments reflected by architecture students (AIAS, 2008; Kirkpatrick, 2018; Leon et al., 2014; RIBA, 2017; RIBA, 2018). The widespread failures of design tutors in making the tacit Hidden Curriculum unequivocal (Austerlitz et al., 2008) often led to tutors coercing learners to faithfully reproduce the dominant value systems and the beliefs of professional practices (Webster, 2005). While few students appeared to thrive under the M&A model, the majority do not (Kirkpatrick, 2018). Could it be that some students are just grittier?

The Curious Constructs of Grit

There is a growing interest in understanding students' personality traits as predictors of academic success, retention and performance within the educational research community. The mindset of 'Grit' is one of them. Grit is defined as having 'passion and perseverance for long-term goals (Duckworth et al., 2007)', fuelled by resilience in the face of failures with a deep commitment for success (Perkins-Gough, 2013). A self-reflective 12 items 'Grit Scale' is a two-factor structured survey consisting of six questions to understand students' Consistencies of Interest and another six, Perseverance of Effort (Duckworth et al., 2007).

Duckworth et al.'s (2007) study amongst Westpoint Military cadets revealed Grit's positive associations with retention. 'Self-control' rather than Grit was revealed as a better predictor of cadets' academic outcomes. The same 2007 manuscript also uncovered that grittier Ivy League students and Scripps National Spelling Bee

competitors (Duckworth et al., 2007; Duckworth et al., 2011) outperformed the less gritter ones. High levels of Grit seem to be beneficial for tasks that are difficult but are well defined. Grit is best inculcated in tandem with sustained 'Deliberate Practice' (Duckworth et al., 2011). Coined by Ericsson (2004), 'Deliberate Practices' are repetitive, purposefully targeted activities that one takes up voluntarily to address specific weakness in their endeavours.

'Reflection-on-action' to Develop Grit in the First-Year Design Studios

Design students need to confide in embracing moments of ambiguity when tackling open-ended challenges. Learning design is a cultural change for beginning design learners, as they continuously yearn for clarities and certainties that vary from their prior learning curricula of closed-end problems (Austerlitz et al., 2008). Wood (2006) defined closed-ended problems when the following three conditions are met: 1) learners are familiar with the procedural methods, 2) data required in solving are provided, and 3) the desired outcomes are clearly stated. Beginning design students' uneasy experiences in this complex cultural transition saw some failing to adapt (Austerlitz et al., 2008). Many first-year students consciously resisted negative emotions of 'failures' by subscribing to the fallacies of believing that they could excel simply by imitating or adhering to tutors' instructions (Webster, 2008).

Grit can only manifest in the face of challenges and pitfalls. It is essential for first-year tutors to facilitate in an empathic manner in bridging learners' introspective thoughts by tactfully guiding them on how to capitalise on their 'reflection-on-actions' process meaningfully. Reflection-on-action occurs when students reflect on the design discussions after their review, during which new perspectives acquired will affect students' experiences, guiding them in processing and structuring their emotions and subsequent actions (Schön, 1987).

Furthermore, Korstange (2016) advocated that by engaging in reflective writing could spur the development of Dweck's Growth Mindsets (an adjacent construct to Grit). Would the traditional design pedagogy of students receiving feedback, accompanied by moments of "reflection-on-action" and "deliberate practices" of imagining and targeting specific design areas for improvement, train students to be grittier? To date, there are limited studies conceived to investigate Grit's relationship with students' academic performance in design/creative education (Rojas, 2015). Prior research (Bush & Arnold, 2020) revealed weak associations between gritty students and improving scores in the context of tracking first-year Industrial Design college students.

Towards A Collaborative Team Learning Pedagogy Culture

This research examined the effects of an alternative non-hierarchical Collaborative Team Learning (CTL) studio pedagogical model that recalibrates the asymmetrical powered structures of the OOO M&A model. The learning experience is conceived as a relationship-driven social constructivist environment where design knowledge is co-constructed in an interactive socialised context, internalised, and acted upon by individuals (Bruning, Schraw & Ronning, 1999; Amineh & Asl, 2015). As a catalyst to cultivate trusting relationships, CTL students select their teammates after bonding through activities during their orientation programme.

The setting up of the desired cross-pollinative team-based 'Community of Practice' studio culture in negating negative emotions of 'design setbacks' (Liow, 2021), inculcating the malleable construct of Grit (Bashant, 2014), is intentionally structured through formative activities in the design brief. The design brief comprises staged interdependent design activities with explicit instructions as 'safety nets' (but with open interpretations), accompanied with 'reflection-on-actions' pointers to assist learners in reflecting on and examining their own and their peers' designs. In contrast to the intuitive M&A's 'Folk Pedagogical' method, CTL's tutor-induced cross-pollinative facilitation will be scaffolded by explicit prompts in the design brief with students working on both communal (not necessarily Group Projects) and individual activities. Design methodologies, workload and course expectations in the design brief demystify the 'Mystery-as-Mastery' folklore. Common milestones and expectations help to ensure that pertinent issues are discussed amongst students.

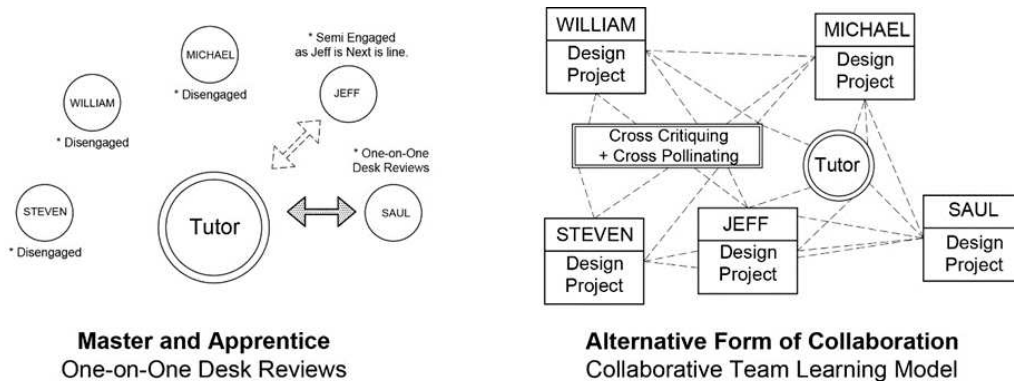


Figure 1. Schematics highlighting the differences between the OOO and CTL studio pedagogical culture.

CTL embraces a dialogical approach to polemical discussions where personal assumptions and biases are challenged in a trusting learning environment with an equitable distribution of power. CTL Tutors take on the role of impartial facilitators since genuine discussions can only occur in non-hierarchical structures (Dutton, 1987) as illustrated in Figure 1. Tutors actively choreograph cross-pollinative peer-to-peer discussions of their individual design projects that contribute to the development of a gritty learning culture (Chang, 2014). These CTL studio's pedagogical mechanisms transmitted as the Hidden Curriculum instils beginning design students' positive and collaborative mindsets, which will turn the tides of the oppressive M&A OOO studio culture.

Research Design

The following sections expound on the Research Context, Research Aim and Questions, Hypothesis and Research Methods.

Research Context

This study is contextualised within the first-years' design studios spanning one academic year consisting of four terms. The study involved 35 first-year, 17 to 18-year-old Generation Z Architecture students from a polytechnic in Singapore, with 16 (11 males and 5 females) immersed in the CTL studio pedagogical culture and 19 learners (11 males and 8 females) taught in the typical OOO M&A format. Students' official contact hours were fixed at having weekly eight-hour studios with a maximum teaching ratio of 1:14. Students worked on an identical design brief and deliverable as a cohort system rather than the non-standardised autonomous Unit-system. 84.2% of OOO (16/19) and 81.3% of CTL students (13/16) reported engaging in self-directed learning (SDL) P2P reviews with two to three peers at least three times a week, as reported at DP1. These SDL P2P sessions are held outside of formal contact hours without their tutors' facilitation.

With reference to Figure 2, first-year students start with an explorative compositional exercise with Lines, Planes and Volumes as the overarching narrative for term 1. Term 2's project comprises a small 10x10m structure comprising ergonomics and anthropometry challenges. The design of a single unit dwelling house straddles between Term 3 and 4 which students conceptualise the macro aspects of the design in the former term, and lead to their detailed construction drawings and in the latter studio term. The 'Design Studio' module is conceived as an integrative activity in which 'Environmental Science', 'Building Construction' and 'Architectural Design' Modules are simultaneously assessed during reviews. Students embark on designing a high-rise residential mid-rise tower in their second year and ends with a public project for their final year. After each project, learners were evaluated in a summative review. A panel comprised four to seven tutors with a joint assessment rubric accessing their creativities/resolutions of their design intentions, strategies, and technical strengths. Tutors' scores were averaged and moderated to determine students' final grades.

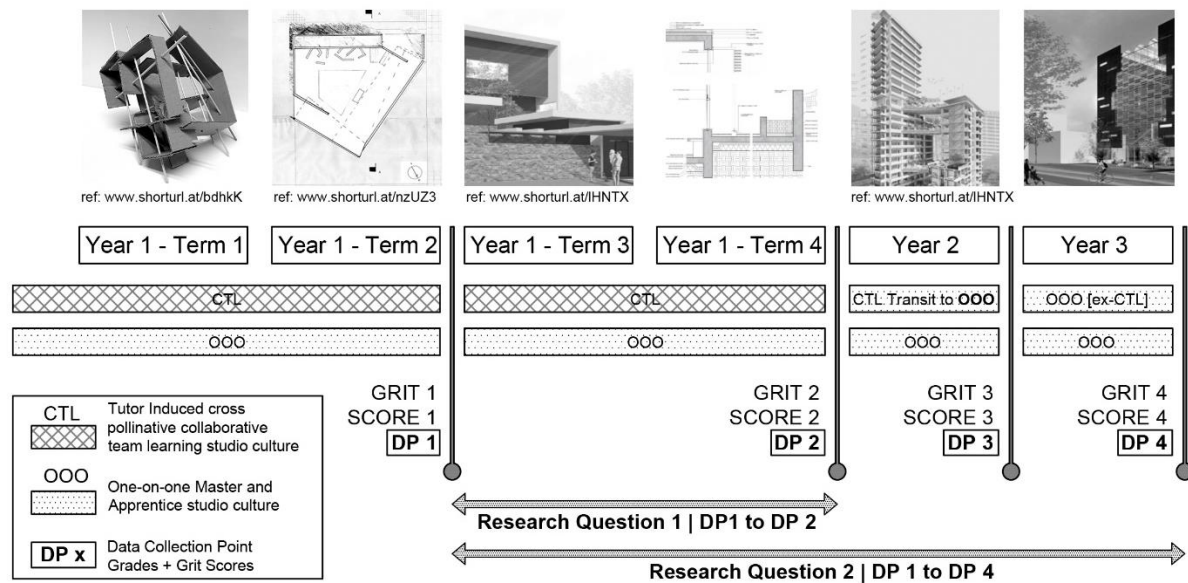


Figure 2. An overview of the Pedagogical Structure for the Architecture programme and the Data Collection Points.

Research Instrument: Measuring Grit

First-year students were introduced to the research project titled 'Learning Experience in the Design Studios' and informed that data would be collected over three years. The four data collection points for their Grit Scores and their respective Design Studio scores (Figure 2) were gathered from the level coordinator. The paper-and-pencil Grit questionnaire was disseminated to the learners before receiving their semester grades so that their reflective emotions would not be stirred by their academic performance.

The '12 question Grit Scale' (Duckworth et al., 2007) is deployed to assess students' level of Grit. Participants rated 12 items, using the scale of 1 = not like me at all to 5 = very much like me. The Grit scale measured two subscales of six items each, Perseverance of Effort and Consistency of Interest. Sample questions for Perseverance of Effort are 'I have overcome setbacks to conquer an important challenge' and 'Setbacks don't discourage me'. The sample questions concerning Consistency of Interest are 'I have been obsessed with a certain idea or project for a short time but later lost interest' and 'I have difficulty maintain my focus on projects that take more than a few months to complete'.

Figure 2 depicts the first data collection point (DP1) after 15 weeks of immersion in the design studio (end of Term 2). Rather than collecting immediately after enrollment, the delay allows first-year students to experience and transit from their previous 'closed-ended' educational structure to the ambiguity of the design studio. At the end of their first year, the second collection data point (DP2) represents a fundamental transition for CTL students to be coached with the OOO pedagogy for their subsequent years of study. DP3 and DP4 were held at the end of Year Two and Year Three. While many Grit researchers use a cross-sectional methodology, this study's longitudinal nature with intermediate data collection points allows students to reflect on and possibly improve their Grit through periodic formative reviews. Multiple data points from the same participant may provide a clearer understanding of learners' Grit for long-term goals.

Research Aim and Questions

The 3 year longitudinal research investigates relationships between learners' Grit scores and their academic performances from both CTL and OOO studio pedagogical cultures. The central hypothesis of this study seeks to uncover if the inculcation of Grit can be naturally exploited within the iterative design process of constantly working and refining designs from everyday studio 'setbacks.' This research also asserts the CTL studio as a catalyst in cultivating students' Grit, as exemplified by the tutor-induced P2P cross-pollinative dialogic pedagogy in creating close-knitted social support structures akin to Wenger's (1999) 'Communities of Practices.' The following research questions are conceived to guide this study.

RQ1: Would the heterarchical CTL studio pedagogical culture accelerate the development of Grit from DP1 to DP2 (when compared to OOO students) and, as a result, academically outperform their OOO peers during their first-year study?

RQ2: Would CTL students continue to advance their Grit scores in the continued practice of self-directing cross-pollinative CTL behaviours and, thus, academically outperform their OOO peers even after transitioning

to the siloed M&A OOO reviews from DP2 to DP4?

Hypothesis and Method for RQ1 [Relationships of Grit and Academic Scores from DP1 to DP2]

RQ1 hypothesises that CTL's heterarchical pedagogical culture hastens their growth in Grit and, as a result, outperforms their OOO peers academically from DP1 to DP2. RQ1's hypotheses are as follows:

Null Hypothesis - H0: μ_2 (Grit & Scores at DP2) - μ_1 (Grit & Scores at DP1) = 0 and

Alternative Hypothesis - H1: μ_2 (Grit & Scores at DP2) - μ_1 (Grit & Scores at DP1) > 0.

Method for RQ1: The first Paired t-test seeks to understand the Pre (DP1) and Post (DP2) differences of CTL students' Grit of testing the CTL intervention's efficacy. A Paired T-test is used to test the significant difference between two related means (Adeyemi, 2009) obtained in matched pairs and are thus dependent (Hsu, 2005). Paired T-tests are performed to assess the intervention's effectiveness using values from a Pre-test and a Post-test. The second Independent t-test seeks out any significant differences in their academic scores at DP2 that would support the hypothesis that Grit's increase is deemed positive by corresponding with CTL's outperformance of their OOO peers. A resultant Probability level (p-value) of less than 0.05 will validate observations of having a substantial difference in the mean values. The relationships of both resulting p-values will help support or refute the premise that CTL's positive instillment of Grit primarily correlates (statistically) with CTL students' academic outperformance.

Hypothesis and Method for RQ2 [Relationships of Grit and Academic Scores from DP1 to DP4]

In the context of the socialised design studio, **RQ2** hypothesises that CTL students' continual practices of informally self-directing their P2P cross-pollinative engagements as 'Communities of Practice' will accelerate their growth in Grit and consequently academically outperform their OOO peers. Hence, RQ2 is interested in the long-term implications of their first year's CTL experience as they transit to the OOO pedagogy in their second year. RQ2's hypotheses are as follows:

Null Hypothesis - H0: μ_2 (Grit & Scores at DP4) - μ_1 (Grit & Scores at DP1) = 0 and

Alternative Hypothesis - H1: μ_2 (Grit & Scores at DP4) - μ_1 (Grit & Scores at DP1) > 0.

Method for RQ2: With a similar framework of RQ1, RQ 2's first Paired t-test seeks the significant growth of students' Grit scores for CTL students from DP1 to DP4. The second Independent t-test aims to tease out significant differences in their academic scores between the two pedagogical groups (OOO and CTL) at DP4 with the hypothesis that CTL learners will academically outperform their OOO peers. The relationships of both p-values will aid in the support/refute of the premise of CTL's continual inculcation of Grit (attributed to the frequent practice of cross-pollinative CTL self-directed P2P discussions) to be further substantiated with CTL's academic outperformance.

Results and Discussions

The following sections discussed the results of the t-tests that attempted to draw relationships between students' inculcation of Grit and their academic scores for the Integrated Design Studio (which consists of various architectural modules) in testing the hypothesis of capitalising on the iterative design process as a natural setting for developing their Grit between the ubiquitous OOO and the alternative heterarchical CTL studio pedagogical culture.

Results of RQ1 [Grit scores and Academic performance during their Year 1 Studies]

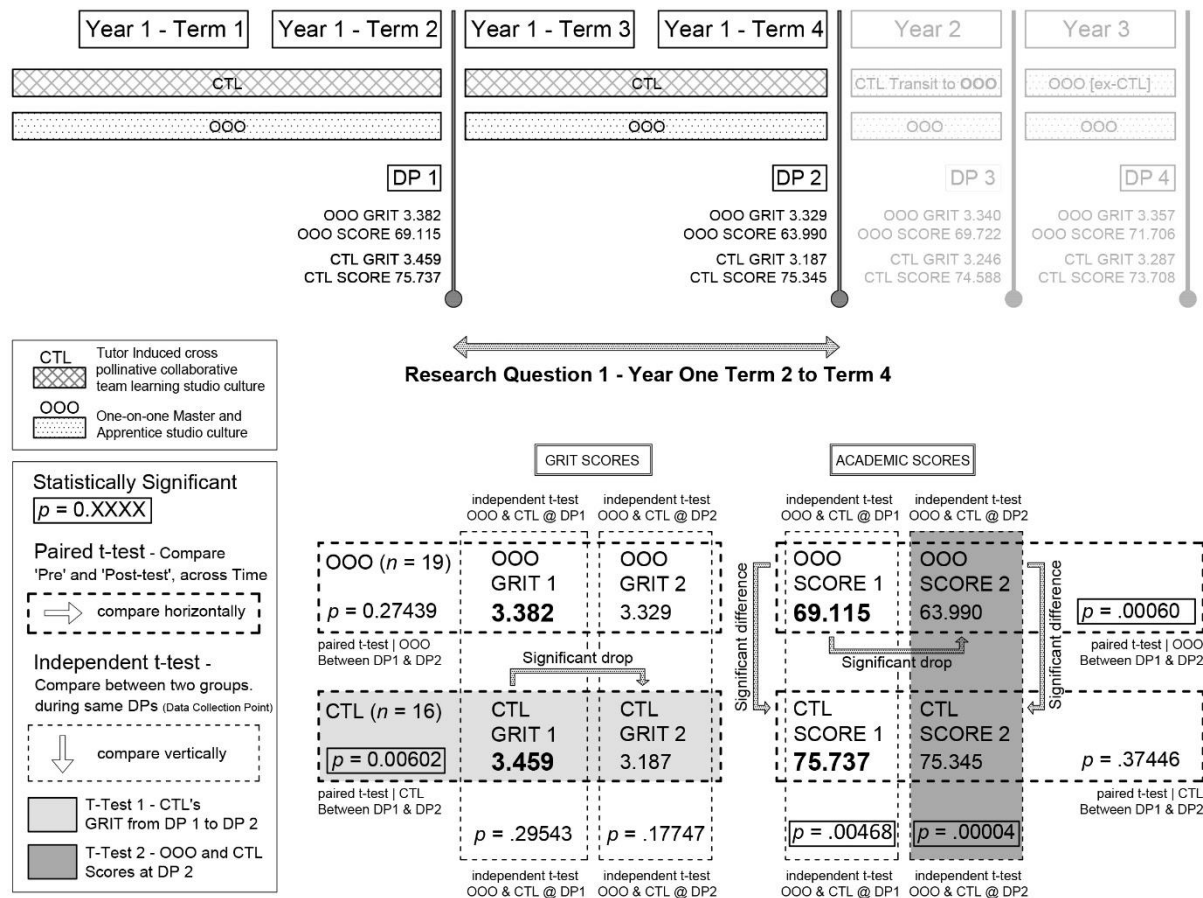


Figure 3. Result table for RQ1 with the comparative t-tests one & two shaded in grey.

RQ 1's observational period was from the middle of Year 1 (DP1) to the end of their freshmen year (DP2). Students' first Grit measurement at DP1 revealed a minimal difference between OOO's 3.382 and CTL's 3.459 ($p = .2954$). CTL students had their grittiness significantly decreased from DP1's 3.459 to DP2's 3.187 ($p = .0060$). Despite CTL students' significant decline in Grit, they have significantly outperformed their OOO peers for both DP1 ($p = .00469$) and DP2 ($p = .00004$). CTL's decline in their academic performance from DP1 to DP2 remained insignificant ($p = .374$). OOO students' Grit remained relatively stable from DP1's 3.382 to DP2's 3.329 ($p = .2743$), but OOO's grades plummeted significantly from 69.115 to 63.990 ($p = .00060$). Unexpectedly, students' Grit levels and academic scores decreased for both groups at the end of their first year.

Discussion of RQ 1

This research explores potential associations between students' Grit and academic performances in an architecture design studio for first-year students participating in two different learning performances. When Grit decreases for both groups, the broader assumption that Grit will be instilled as a by-product of capitalising from the iterative design process is invalidated. The first t-test reflected CTL student's significant decline of Grit from DP1 to DP2, which has nullified the alternative hypothesis of CTL learners' advancement in Grit compared to their OOO peers. This finding contradicts Chang's (2014) proposition that collaborative engagements promote the development of Grit.

Having a Growth Mindset is an essential attribute among design students as it helps them navigate through the uncertain process in design disciplines (Dweck, 2008). The open-ended nature of design pedagogy requires an agile mindset capable of absorbing new information and criticism while evaluating its applicability to student's own design. Could Grits' *perseverance*, defined as 'continued effort and determination' (Cambridge Dictionary, n.d.), be a strong-willed construct obstructing the open-ended design process? Beginning design students' fixated mindsets with preconceived notions of appropriating 'seductive' images online (Liow, 2021) may not have felt the necessity for a rigorous process, thus negating the exercise and

development of Grit.

Even with decreasing Grit, CTL students outperformed their OOO peers on both DPs, suggesting CTL's pedagogical culture's ability to yield academic benefits. Researchers have advocated that the social aspects of higher education are highly contributing to students' success (Felten & Lambert, 2020). Having peers' active and focused involvement in collaborating on another's design process helps to ignite and sustain learners' passion for their work (Perrewé, Hochwarter, Ferris, McAllister, & Harris, 2014). CTL's tutor-induced peer support structure creates a studio environment characterised by high expectation with high support. The fostering of quality supportive friendships strengthen learner's abilities in dealing with setbacks (Graber, Turner, and Madill, 2016) of the ambiguous design studios. CTL's outperformance, which contrasts with their declining Grit, is intriguing. CTL students may have reflected on and given themselves negative, depressed self-ratings that were mistakenly associated with their laborious and rigorous design process. Hence, the narratives for the resulting disparity remains inconclusive. Future research should consider collecting and analysing qualitative data to uncover new insights into learners' lived experiences.

OOO's academic performance had curiously plummeted significantly from DP1 to DP2. Theoretically, OOO learners immersed in an M&A tutor-centred setting should outperform their CTL counterparts. During summative reviews, it was observed that OOO students appeared to be entrenched with the 'closed-ended' pedagogy of their prior educational system. OOO students are purportedly misled by assuming that their designs, being rigidly supervised by their tutors, is without flaws and does not require any improvements. Their unpreparedness to take ownership of their own design process by not questioning the tutor's, as well as their underlying preconceptions and biases, were frequently uncovered during summative review's Q&A. M&A tutors' hunch in dispensing 'certainties' by providing visual references for students' inspirations and adherence in clearing OOO students' cloud of confusions (Green & Bonollo, 2003) are detrimental in developing learners' confidence and perseverance for the ambiguous design process (Liow, 2021). This cushioned safety net, of having lesser occurrences of the design studios' daily 'design setbacks', could be explained by OOO's modest decline in Grit.

Results of Answer RQ2 [Grit scores and Academic performance from their Year 1 to year 3 Studies]

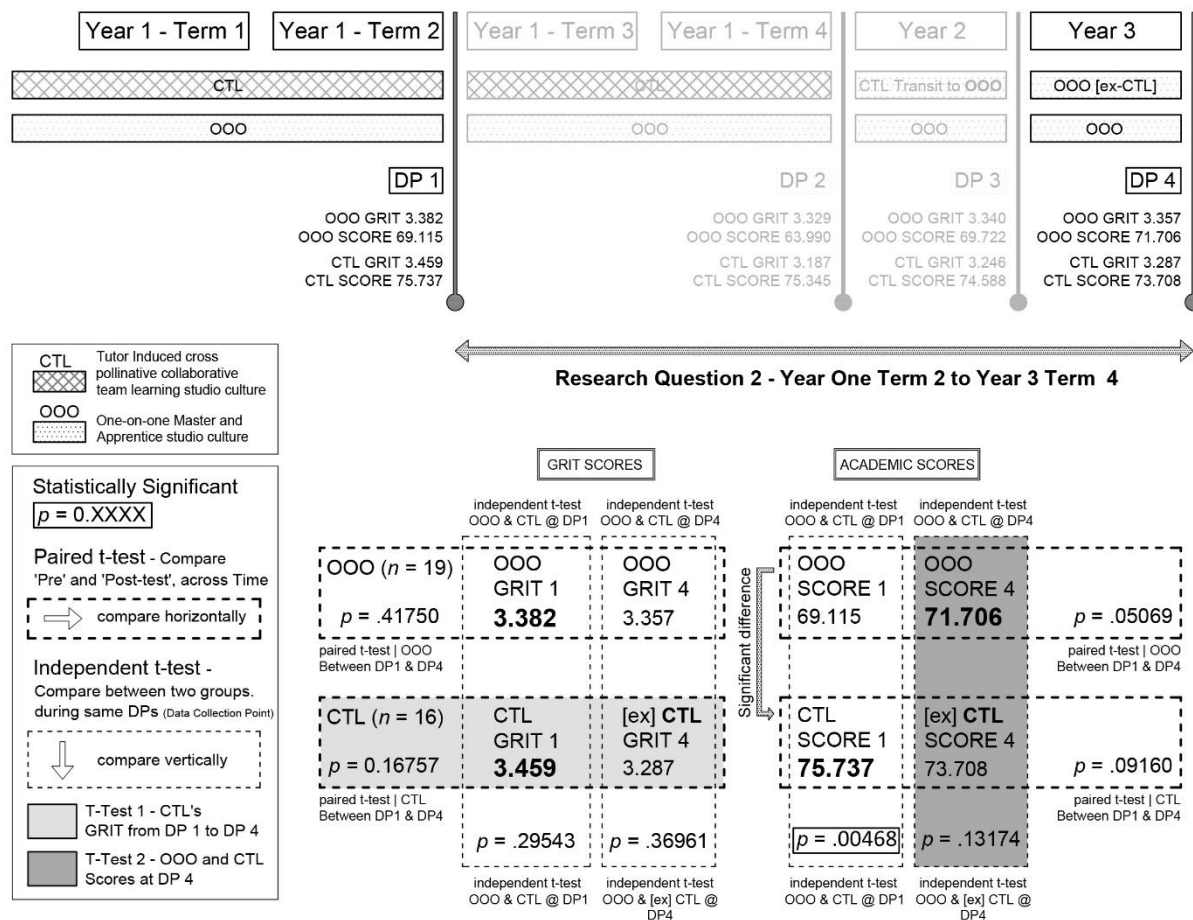


Figure 4. Result table for RQ2 with the two main comparative t-tests shaded in grey.

As Grit is defined as having sustained passion and perseverance through prolonged periods of experiencing challenges (Duckworth et al., 2007), RQ2's extended tracking spans from DP1 to DP4. CTL learners' Grit scores maintained a gentle decline from DP1's 3.459 to DP4's 3.287 with a p-value of .1675 (but recovered from DP2's dip to 3.187, resulting in a significant decrease) in their transition to an OOO studio pedagogical culture. CTL's academic scores decreased from the DP1's 75.737 to DP4's 73.708 ($p = .0916$). Although the Grit of OOO students fell over the next 2.5 years from DP1's 3.382 to DP4's 3.357 ($p = .4175$), their academic performance improved from 69.115 to 71.706 ($p = .0506$). OOO's academic scores at DP4 of 71.706 is closing the gap with CTL's 73.708. However, their resultant p-value of .1347 revealed little significance.

Discussion of RQ2

RQ2 investigates whether CTL students' transition to the siloed OOO M&A desk crits would maintain their improvements in Grit concurrently with outperforming academic scores. As the negative trend in Grit and academic performance from DP1 continues, RQ2's alternate hypothesis that CTL students' academic outperformance is possibly due to increasing Grit and involvements in their self-directed P2P cross-pollinative practises is rejected. Cross-pollinative design discussions practised casually amongst CTL peers even after transiting into the OOO pedagogy (as revealed to the author during CTL's focus group interviews) may not have been successfully bridged and facilitated through their senior years. This finding suggests that the tutor's continual facilitation is required to ensure the continual reaping of CTL studio pedagogical culture's benefits. The knowledge and confidence to ask relevant questions to spur the creative process require the maturity of the experienced mind. To encourage such behaviours, CTL's choreographed cross-pollinative discussions enable the inculcation of a positive 'Hidden Curriculum', in which CTL learners acquire competencies of asking questions by observing the tutor and their peers. This affirmative enculturation of inquisitive behaviours requires tutors' constant scaffolding to be effective, as learners are likely to struggle with the questioning process without a tutor-led environment (Ghassan & Bohemia, 2015).

In comparison to their CTL peers, OOO's decline in Grit was modest, particularly considering their improved academic performance at DP4. Their academic improvement suggests the successful enculturation of the OOO's studio habits and culture characterised by strict compliance with the M&A instructive pedagogy. Beginning design OOO students who underperformed at DP1 may have begun the course optimistically by challenging the tutor's instructions and not wholly conforming to the tutor's wishes. After OOO students had reflected upon their grades, they might revise their strategies of 'rebelliously questioning tutors' and their underlying assumptions' to the 'adherence to strict regimens' to ensure that their grades are not jeopardised (Liow, 2021). After all, senior design students are more acculturated to playing the M&A's game of bluff by initiating surface-level dialogical reviews and blindly [re]producing solutions tailored to the tutor's preferred design paradigms in return for good grades (Webster, 2005). Students putting on a veiled façade in exchange for grades through conforming to the tutors' instruction is not novel. Braaten (1964), a psychologist, had noticed similar behaviours in architecture studios about a half-century before!

Validities of Self-Reported Measures

Any self-reflective measure's accuracy should be analysed with caution. Researchers have uncovered weak positive correlations between student self-ratings and other measures (Sarin & Headley, 2002 & Brown, Andrade & Chen, 2013). In Asia, where cultural behaviours such as self-effacement (Kwok & Lai, 1993) and humility are prevalent, students frequently reported depressed self-evaluations. Self-assessments' validity is also highly dependent on the academic calibre as high achieving learners are revealed to possess a higher ability to perform self-assessments than low-performing peers (Sarin et al., 2002).

A Final Ditched Attempt Seeking Relationships of Grit and Academic scores

Merging all data collection points (DP1 to DP4) as a singular dataset representing the student's entire duration with the institution, this section explored the possible correlation between students' (both OOO and CTL) academic and Grit scores.

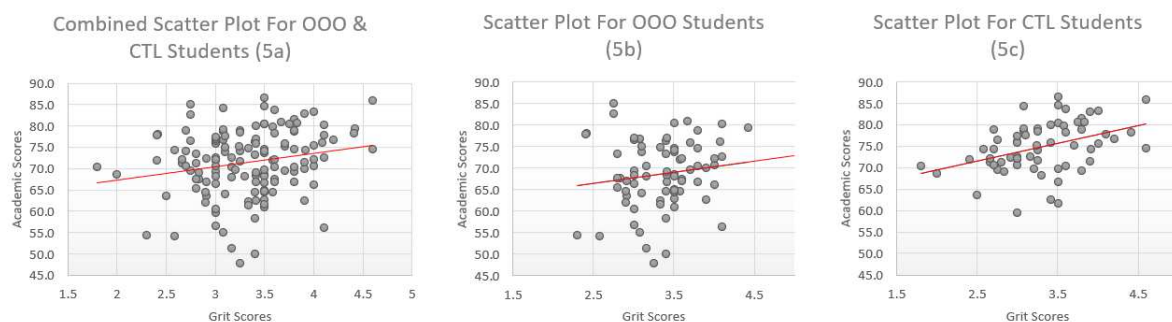


Figure 5(a to c). Scatterplots reflecting the relationships between Grits and Academic Scores.

A 'weak positive' correlation of Grit with Scores ($r = 0.2046$) is reflected for the cohort in Figure 5a. Correlation for OOO students (Figure 5b) resulted in a 'very weak positive' relationship ($r = 0.1439$) while CTL learners' correlation (Figure 5c) is 'moderate positive' ($r = 0.40300$). Although not an ideal 'strong correlation' by CTL learners, the moderate positive correlation does suggest Sarin et al.'s (2002) notion of higher calibre students' abilities to conduct accurate self-assessments.

Conclusion

Mental health issues arising from the oppressive OOO M&A design studio are not novel predicaments (Braaten, 1964; Kirkpatrick, 2018). Even after centuries, design educators have stayed lukewarm in experimenting with alternative studio pedagogies in challenging the pervasive authoritarian M&A cultural relations. Design tutors were generally unaware of the benefits of shifting the hierarchical line (Goldschmidt et al., 2014), and a lack of pedagogical training (Webster, 2005) has consistently left demotivated students in the ditch.

The focus of this research is to ascertain if the instillment of Grit is effective within the iterative design process, particularly in a heterarchical design pedagogical culture where the tutor-induced P2P cross-pollinative dialogic approach seeks to normalise daily 'design setbacks'. Grit was discovered to have little correlation with both academic scores and the varying studio cultures. The consistent decline in Grit readings throughout the

2.5 years is perplexing. The insignificant relations between Grit and learners' academic performance in a design studio presented in this study is echoed by Credé, Tynan & Harms (2017). According to Credé et al. (2017), ill-defined tasks that require both creativity and the willingness to abandon unsuccessful strategies may be counterproductive if students are gritty. Being too gritty might backfire against the iterative design process characterised by uncertainties and ambiguities. Although the concept of instilling Grit may appear to be less relevant in design education, tutor-induced cross-pollinative CTL pedagogy has successfully ripped educational benefits. To better understand learners' lived experiences, future research should analyse qualitative data collected through focus groups/semi-structured interviews.

Studio Culture: A Heterarchically Structured Hidden Curriculum

In the 21st century of accelerated change, the hierarchical organisational values we have inherited from the procedural industrial revolution must be urgently questioned. With the influx of Generation Z learners entering higher education, the M&A pedagogy is no longer deemed relevant nor appropriate in engaging them. The design studio can take advantage of Generation Z's preferred learning traits, favouring collaboration over a hierarchical and dispensational model of pedagogy (Schwieger & Ladwig, 2018; Rue, 2018), to create an alternative heterarchical studio pedagogical culture.

It takes two hands to clap. Tutors' buy-in to teach in a non-hierarchical structure as facilitators, prompting and guiding students by mindfully inducing cross-pollinations in a team setting is essential. Through structured design briefs that help construct cross-pollinative conversations through interdependent bite-sized design exercises, beginning design students model behaviours and dialogues that encourage mindsets to normalise daily 'setbacks' of the ambiguous design process (Liow, 2021). It is vital to instil in first-year students the willingness to question their assumptions and participate actively in polemical discussions. It is observed that in the author's first year's design studio, the incubation period for the CTL mechanism to be running on 'autopilot' mode is approximately six instructional months.

As design education's precarious tutoring force predominantly comprises adjunct practitioners (mostly from modest-sized practices), whose agendas and value systems are arguably biased toward developing ground-breaking formal expressions, their pedagogy inevitably favours stylistic outcomes through mimicry remain faithful to the ambiguous design process. An overly practice-orientated tutoring mindset (overly biased on achieving stylistic/ pragmatic outcomes as 'survival strategies' in the volatile market) will take precedence over tutors' motivations for the advancement and reflections of pedagogical research and practice. The oppressive cultures of the M&A pedagogy, shaped by the Hidden Curriculum's questionable habits, behaviours, and value systems, will continue to deeply permeate their professional practices and infuse them back into academia as design tutors in an endless cycle. The non-hierarchical CTL studio pedagogical culture seeks to turn the tide, one studio at a time.

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Nordic Life Design

A holistic approach and attitude to life

Kirsten Bonde Sørensen

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When discussing future education, we tend to focus on defining future competencies and discussions on preparing students for an everchanging labor market with job titles we cannot yet imagine. We tend to oversee that our students, for years, have been among the human beings characterized as having the highest degree of mental challenges, which indicates a real need not only for new initiatives but for radical transformations in education. Initiatives that represent a more humanistic and holistic view, combining a broader focus on education, including newer knowledge and a clear and heavy focus on students' lives, well-being, and vitality. This paper describes Nordic Life Design, a learning concept rooted in design theory and -practice, including knowledge from cognition, creativity, and brain science. The intention is to educate student not only for working life in a complex and ever-changing world, but for life in general. The paper adds examples of incorporating the concept in the higher education curriculum.

Keywords: future education; paradigmatic shift; values; reframing; life design attitude

Our paradigmatic shift demands a new approach and mindset

We are in the middle of a paradigmatic shift, moving from an industrial society dominated by analysis, control, streamlining and order into a learning society dominated by creativity, intuition, chaos, and change. According to Wagner (2014) the paradigmatic shift has created an ever-widening skill gap between what schools are teaching and what buyers need. Nevertheless, there is an even more essential and ever-widening gap between what schools are teaching and what the students need to create a good and meaningful life. The move from the industrial society into the learning and knowledge society is also a move from industrial workers to knowledge workers, from life in stability and control into life in unpredictability, uncertainty, and change - and a life where knowledge workers are searching not for money, but for meaning (Sinek, 2009, 2017). This movement creates chaos, stress, insecurity, and most of all, a need for learning new human skills, competencies, and ways of being. Predicting the future is difficult, but as Wells and Claxton (2008) argues, one thing seems clear: "Students will need to be better equipped to successfully navigate the increasingly complex and ill-defined nature of life in the 21st century". This paper considers mental health issues to be related to this paradigmatic shift.

Mental health among students

Several reports demonstrate a high level of stress also among young people in higher education, in Denmark 33% feel a high level of stress (EVA, 2019). In the US 87% of students have experienced stress during their college years. 45% of college students claim to go through "more than average stress." Only 11% of students in the US sleep well. A Uni Health study in the UK (unihealth.uk.com, May 2019) found that 80% of those studying in higher education reported symptoms of stress or anxiety. Numbers that only have increased with the Covid crisis due to a recent report by American Psychological Association, in which stress is termed 'a national mental health crises'.

Experts present various reasons for the mental health crisis among young people: some point to increased use of SoMe and FOMO (fear of missing out) (Rose, 2019) or the future precarious working life (Hyggen, 2019) the



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challenging structural frameworks in education (Warming, 2019) or a double pressure: a social and a professional pressure (Ejrnæs, 2019). Katznelson (2018), professor and leader of the Center for Youth Research, directly points to industrial values, arguing that the performance culture limits young people in general. Young people feel controlled by external factors as outer requirements and expectations from educational institutions, societal norms, like being successful and creating a happy life. In a recent publication, eleven researchers (Görllich et al., 2019) argue current that vulnerability is changing expression. Till now, it has been thoroughly demonstrated that social heritage is crucial for young people's level of education, life chances and well-being. Now middle-class youth are increasingly being affected as well.

Katznelson (2018) recommends that young people learn life skills and list several things important for young people to learn: young people must learn to sense themselves and understand what is essential and valuable to them and what they need. Also, young people need to learn to think creatively, learn flexible thinking, and think in plan a, b and c. To summarize, Katznelson argues, young people need "tools for life's maze".

In a student research at Danish School of Media and Journalism on 'Mental health among student' a class consisting of 35 participating students conducted a research including 175 students, another class consisting of 98 participating students conducted a research including 490 students. From this research one significant insight was, how students predominantly consider mental health to be a private issue that includes feeling guilty and shameful. An insight confirmed by Petersen in Görllich et al. (2019, 82).

Definition of mental health

There are varying definitions of mental health. In this research, we apply the definition made by the World Health Organization, which is "a state of well-being in which the individual realizes his or her abilities, can cope with the normal stresses of life, can work productively and fruitfully, and can make a contribution to his or her community". This definition includes both an inner and an outer focus. The crucial question is How? and not most minor Where? - and additionally, who owns this problem? However, the definition also leaves many questions to clarify definitions, like What includes 'realizing own abilities'? How to define 'the normal stresses of life'? However, as defined by WHO, mental health can only be achieved if students can cope with the everchanging surroundings. Before 'realizing own abilities', 'coping with normal stresses of life', a crucial factor will be to cope with the VUCA world (Bennis & Nanus, 1985) – an acronym describing the world as Volatility, Uncertainty, Complexity and Ambiguity. VUCA world describes the unpredictable nature of the world at stake, as the situation of COVID 19. A claim that will be elaborated in the following section about educational development and 'change agents' in education.

Recommendations for future education

Researching recommendations for future education is relatively comprehensive. This paper focus on learning experts, who argue education needs a transformation (Robinson, 2009, 2016, 2020 Claxton 2004, 2018, Wagner, 2014, Kreluik et al. 2013, OECD, 2018). This research builds on OECD's (2018) recommendations concerning future skills and future education. OECD argues young people must become 'change agents' (2018): young people need 'a broad set of knowledge, skills, approaches and values in action'. These skills are all described as 'transformative skills' and constitute relevant meta-skills or -competencies:

- Creating new value – to think creatively, create new knowledge, collaboration, co-creation, collaboration, curiosity, open-mindedness
- Reconciling/balancing tensions and dilemmas - see more perspectives, systemic thinking, understanding others, empathy.
- Take responsibility
- To see consequences - self-regulation, self-control, confidence in one's abilities.

Some will argue that not all of us must become change agents. However, if we think of our grandparents, they represent human beings from another time of history and another approach to life. Today, we need another approach, attitudes, and skills to embrace a world far more complex and in constant change.

Reframing industrial values into new values that fit our learning society

The above insights open to new questions related to essential concepts as 'learning', 'creativity' and 'life & human beings'. Moving into a new paradigm there is a need for reframing values and understandings:

A 'new' understanding of learning & learners

There are many discussions on what students should learn. Yet, as we do not know the future and what type

of knowledge and methods we need, the most important thing is learning to learn, and even learning to unlearn and relearn (Grant, 2021). Learning is considered an essential part of well-being: To learning experts (Illeris, 2014, Lucas & Claxton, 2009) learning is not limited to school and education. It reaches everywhere and throughout life as a ubiquitous feature of life. To Lucas & Claxton, lifelong learning is built into our evolutionary bones and explain that "People who are used to learning and skilled at it, are less likely to be caught on the hop when circumstances change. They are more ready to rise to the challenge..." To Lucas & Claxton, lifelong learning is not a choice but an inevitability, moreover. Also, learning is related to well-being, achieved by choosing worthwhile forms of difficulty to engage in, in a self-chosen challenge. The researchers even argue that the health of individuals, communities and societies depends on learning encouragement. People live and age better when they have the opportunity and the desire to learn new things. There are different paradigms within learning: the behavioristic view of learning is rooted in the industrial society, whereas learning described by Lucas and Claxton (2009) as well as transformative learning described by Illeris (2014) and Mezirow (1996) represent the constructivist perspective where learners continuously interpret their sense of existence to create meaning or develop alternative views. A perspective relevant in to 4-foci model (to be presented) and relevant in training students to create value and meaning in their lives.

In a 'liquid modernity' (Bauman, 2020) society is in a constant change, which adds some far-reaching demands to our learning, as it reaches everywhere and throughout life and is not limited to school and education. Due to Illeris (2014), constant change is actualizing the concept of 'transformative learning'. Everything is constantly changing, like identity formation and -reformation, young people's self-world and transformative learning. Mezirow (1996) introduced the concept: the transformative learning theory, which he characterizes as a type of learning and "the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (p. 162). Transformative learning can help us broaden our perspectives, transform outdated values and beliefs, it can help us rethink and unlearn. We often think of intelligence as the ability to think and learn, but in an increasingly complex and changing world, another trait is even more important, the ability to rethink and unlearn (Grant, 2021)



Figure 1. Illustration of transformative learning (Kali, Y. 2016)

Precondition for learning and becoming a successful learner is attitude, beliefs and assumptions. Carol Dweck (2006) demonstrated that beliefs remain open to modification also in adulthood. Dweck studies human motivation and claims two mindsets: a 'growth mindset' opposite to a 'fixed mindset'. Whether conscious or subconscious, our basic beliefs are compelling. Dweck argues our beliefs strongly "affect what we want and whether we succeed in getting it." Much of what we think we understand of our personality comes from our "mindset", which propels us and prevents us from fulfilling our potential. Likewise, Resnick and Perkins have revised the concept of intelligence to focus more on qualities of the mind that are malleable than those that are supposedly fixed, and therefore beyond the educator's ability to influence. Resnick defines intelligence as 'the total of one's habits of mind'. Lucas and Claxton elaborate, "...that in fields such as sports and music, where the idea of innate 'talent' is firmly embedded, it turns out, that these factors play a much smaller role than commonly thought, and some even question whether they exist at all".

Based on this knowledge teachers ought to create higher awareness on how to become successful learners and the crucial preconditions for learning: attitude, beliefs, and assumptions. Additionally, we need to incorporate knowledge about 'embodied cognition' (Lakoff & Johnson, 1980). For years, we thought human beings were thinking and perceiving only with their brains, which is the reason for our traditional mentalistic types of learning that separate the mind from the body. However, according to embodied cognition, cognition is shaped by aspects of the entire body. This recognition accentuates the values in creative, designerly and

aesthetic learning principles, that makes learning more effective (Austrius & Sørensen, 2006).

A 'new' understanding of creativity

People often assume that the term creativity only applies to ideas and even to breakthrough ideas – a focus on the so-called big-C rather than little-c creativity (Kaufman & Beghetto, 2009). Also, in the knowledge economy, creativity is seen as a goal-oriented competence used for idea development and innovation in a workplace (Stepper-Larsen, 2011). However, in creativity research, creativity is not restricted to isolated mental processes, which can materialize everywhere, instead creativity is seen as a socio-cultural phenomenon and considered an essential way of creating ourselves and in changing perspectives and worldviews. This view of creativity relocates creativity from inside individual minds to the material, symbolic and social world of culture, also termed cultural psychology (Tanggaard, 2015 in Gillespie et al., 2015)

For years ago, Maxine Greene, an American educational philosopher, argued that young people have 'to create themselves' (Greene, 1978, 1995). They must create value and meaning in their lives. In the socio-cultural field of creativity research, creativity is considered an essential resource in constructing and developing a person's identity (Bardot, 2008, Bardot & Lubart, 2012, Getz & Lubart, 1998). Also, creativity contributes to setting one's course in life and defining one's orientation. Thus, creativity represents an essential resource in identity construction and the development of 'a life project'. To help youth build their identity and life project is a valuable goal of educational systems (Valverde, Sovet & Lubart, 2017). Creativity concerning identity construction and life projects is rooted in and an example of 'mini-c creativity' (Kaufman & Beghetto, 2009). A parallel to Zittoun's (2015) description of Life Creativity is Hammershøj (2014), who claims creativity is a question of *bildung*. *Bildung* is a German word and describes the relationship between the individual and the world. The basic assumption is that the formation of the personality can only occur through the transcendence of the self into the social (Schmidt, 1999).

As formation is an essential, but overseen, part of education, the above knowledge is relevant in future education. As Maxine Greene argues, "Part of teaching is helping people create themselves". Future education needs to be better at helping students create themselves, attune to a more creative attitude and recognize creativity as an essential human capacity in life (Lucas, 2019, Melles et al. 2013).

A 'new' understanding of 'life' as a creative learning process and 'human beings' as creators of value and meaning in life

Young people are dominated by the performance culture (Katznelson, 2018) and believe that life is a straight and successful up-going line filled with happy Insta-moments. However, normal life is filled with ups and downs, joys and sorrows, and fate and freedom. As Knoop (2015) argues: "It is essential to understand the complementary relationship from birth to death. We live a self-organizing life under compelling circumstances - that means we both must come to terms with and create. It is both and every single second throughout life". Presenting life as a creative learning process reframes 'life' from as 'a performance' into life as an exciting playground and learning process.

Being a creator of our lives is also accentuated with newer knowledge in cognition and brain science. We can rewire our brains and our habitual thoughts and behavior (Langer, 2009, 2016). Also, we can control our thought, and thus our emotions (David, 2016). Despite this not new knowledge, we still need to use and spread this knowledge to students. We can control our attention towards our dominating thoughts (also termed meta-cognitive therapy, (Wells, A. 2011, Callesen, P. 2017) is a simple but effective method and treatment to overcome stress and other mental challenges. Likewise, 'emotional agility' (David, 2016) and related methods can help students. Working with our imagination and our thoughts are related to our creative way of thinking and doing. Therefore, our creativity is a crucial and central human resource that we need to strengthen and cultivate – particularly in education

In cultural psychology creativity, there are different suggestions to how life can be seen as a creative process. Tanggaard 2015) considers the conduct of life itself to be a creative act and argues that we need to study everyday life's creative pathways. Hammershøj (2014) argues creativity is a question of *Bildung* and compares life to a creative process. 'Life-creativity' is defined as a way to create a life-path, a 'possibility thinking' (Craft, 2000). Life-creativity is presented as the contrary of automatism or constrained repetition - a parallel to Langer's definition of 'mindful' opposed to 'mindless' living (Langer, 2016).

The design approach represents a 'new' creative and holistic approach

Opposite to creativity, design is a well-described creative profession with a research foundation. However, to many, design still refers to product design like a beautiful lamp or chair, or some might think of interaction

design as Apple products or the like, but design is much more than that. In the last decades, there has been an increasing interest in the underlying creative process, approach, and mindset behind the final solutions. The designer is characterized by an overall design approach, an attitude (Boland & Collopy, 2004, Michlewski, 2014) and an additional practice. Design has increased attention as design represents an approach that differs radically from the rational and analytic approach, which fit the industrial age's linearity and predictability (Boland & Collopy, 2004, Michlewski, 2014).

In the last decades, design has proven to be a valuable approach in various fields (designcouncil.co.uk). In the history of design, the understanding and practice of design have moved from 1st order of design to 4th order of design (Buchanan, 2001); from graphic design to the design of complex systems. Design has been introduced as 'a process' and 'a method' (Lawson, 2005, Lawson & Dorst, 2009); 'a revolution' (Fuller, 1964, Sanders, 2006); 'a new culture' (Nelson & Stolterman, 2012); as 'designerly ways' of knowing and being (Cross, 1982) and 'a new' attitude (Boland & Collopy, 2004, Michlewski, 2014, Rawsthorn, 2018). In 1957 Fuller introduced the concept of 'Comprehensive Anticipatory Design Science' and argued that the world needed a 'design science revolution'. Fuller coined the term the 'comprehensive designer', asserting that design could be more than a stage in the manufacturing process associated with the Cold War industry; it could be 'a world-saving way of life' (Chu & Trujillo, 2009). In that sense, Fuller was the first person to use design thinking for planetary sustainability. Today, we often distinguish between different types of sustainability: human, social, economic, and environmental sustainability (Godland, 2002). Presumably, Fuller was focused on economic and environmental sustainability.

This paper argues it is time for elaborating and developing Fuller's concept and introducing design not only as a revolutionary approach to planetary sustainability, but as a broader and more holistic type of sustainability that also includes the individual, human life. Training human beings to become 'holistic designers', not only in the world but also in their lives, could be an answer and a solution to the increasing and worrying number of people, particularly young students, who fail to thrive.

Nordic life design

Nordic Life Design is a learning concept that aims at helping and empowering students to become better prepared for a complex, ambiguous and everchanging world. Nordic Life Design is aimed at enlarging students' perspectives and relationships to others and to themselves. Nordic Life Design (includes a 4-foci model that works together with a Nordic Life Design Attitude. The concept represents a holistic learning concept that breaks with the current and industrial based assumption that educational institutions should focus only on educating students for their professional lives. The research recommends that educational institutions should have two precise tasks:

1. educating students for life – offering creative life mastery skills and
2. educating students with skills, competencies, and ways of being relevant in a complex and everchanging world – offering a design attitude including design skills and -competencies.

The concept seeks to meet with current needs among students, but it also seeks to treat the cause of the problem: Students need both concrete knowledge and life mastery skills (Katznelson, 2018) and knowledge, skills and competencies that fits the VUCA world (OECD, 2018). However, from our student research, being challenged by stress or other mental issues, the students feel guilt and shame, which points to a need for reframing this problem and turning it into a structural problem belonging to educational institutions. The problem is highly current as Görlich et al. (2019) claim any student is now potentially vulnerable.

Nordic Life Design sees life as 'a creative learning process' and human beings as 'designers in their lives' and 'co-designers in other people's lives and the world'. In that sense the concept also seeks to challenge our industrial values, performance culture and focus on the individual. Instead, we suggest we need to become *designers in our own lives* and *co-designers in other people's lives* and seeing life as a creative learning process. The concept is based on existing research. In design theory design is described as a 'multifaceted nature' with various definitions and activities (Lawson & Dorst, 2009, Lawson, 2005). In 2004 Boland & Collopy introduced the notions 'Design Attitude' as opposed to 'Decision Attitude'. The authors claimed business education needed a new approach. Inspired by Frank Gehry's designerly approach to business, they introduced the creative 'Design Attitude' that stood in contrast to the rational and analytic 'Decision Attitude'. Later, based on a study of designers working in organizations, Michlewski (2016) made a deeper characterization of the notion of 'Design Attitude' describing five characteristics.

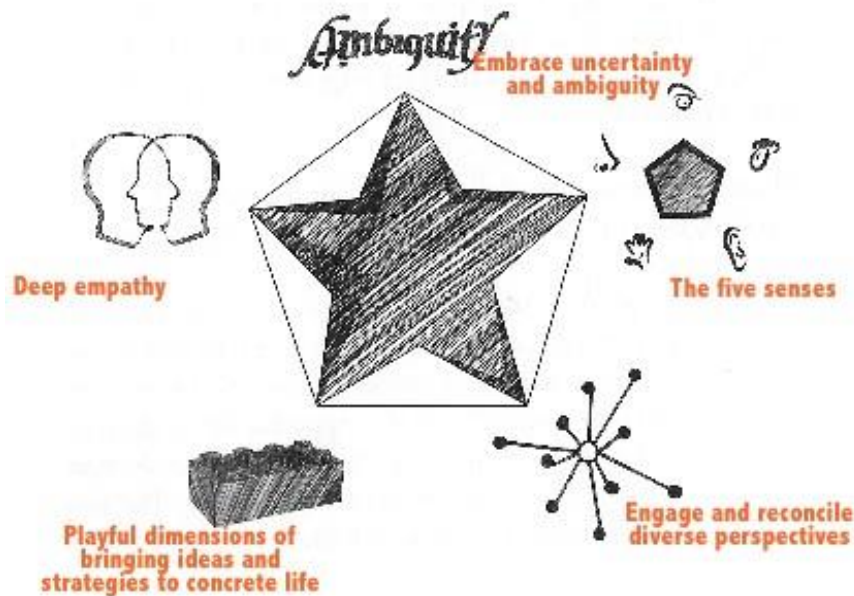


Figure 2. Design attitude (Michlewski, 2014)

However, Michlewski's definition of 'design attitude' is based on studies in business organizations and focuses on design as a profession in organizations, that means work-life. In an overall perspective, 'the decision attitude' and 'the design attitude' can be seen as stereotypes that represent different mindsets in the industrial society and the approaching knowledge- and learning society. In this paradigmatic shift the industrial values (represented in an intense focus on measurement, control, and efficiency) and activities (like thinking primarily rationally, analytically, and linear etc.) are outdated and prevent us from adapting to this 'new' knowledge- and learning society. Rashid (2021) distinguishes between an industrial society focused on 'measurement' and a society focused on human beings and on 'sensing and being'. He argues, people are "drowning in their everyday lives"- they have difficulties sensing themselves, living a life, increasingly dominated by external control, unpredictability, and a growing loss of control (2021, 74). To Rashid, this explains the growing numbers of stress and mental challenges among people, and young people (Katznelson, 2019). To adopt to this paradigmatic shift, we need to be able to think in new ways, to approach increasingly complex problems, to be in chaos and most of all, to include our human capacities: our senses, emotions, creativity, intuition etc. These human capacities are crucial and a precondition for sensing yourself. Consequently, Nordic Life Design includes a 4-foci model, that accentuates 'an inner focus' and the relationship to other foci. Training a life design attitude includes both imagining, different types of thinking, ways of being as well as concrete designerly activities. Nordic Life Design Attitude consists of nine elements that root in Michlewski's characteristics. Yet, some of the characteristics are defined in other ways that include more precise descriptions that refer to the activities in Nordic Life Design, e.g. 'engage or reconcile diverse perspectives' are described as the design activity: 'framing/ reframing'. Likewise, 'playful dimension...' is explained as 'thinking with your hands, materializing and expressing yourself'. The descriptions are based on other researchers' characteristics of design activities (Lawson, 2005, Lawson & Dorst, 2009, Kolko, 2010). Additionally, we have added elements that are central in life, like 'being open minded, focused and trying things out' (Burnett & Evans, 2016) and of course the crucial 'understanding our body and brain, thoughts, and emotions', which is crucial in the life design attitude and its inner focus.

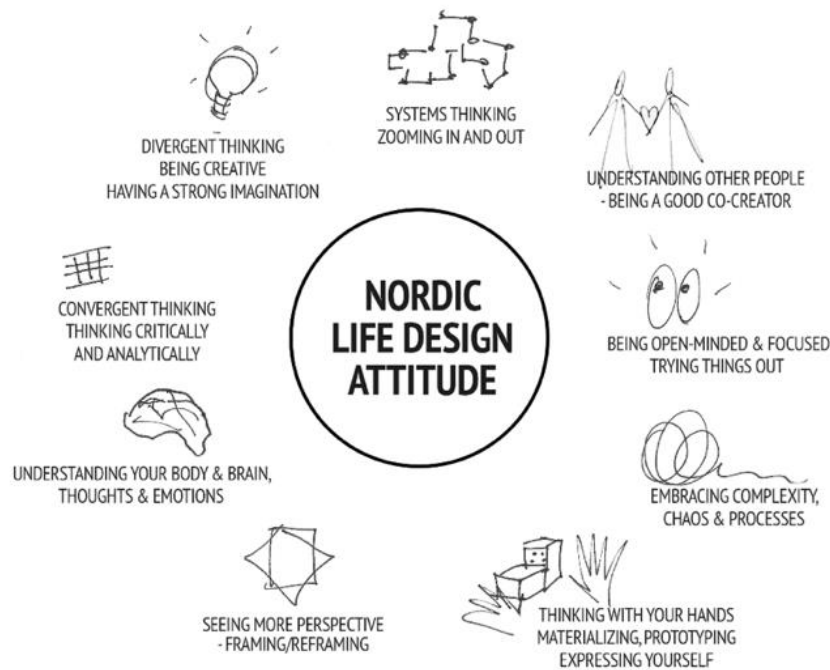


Figure 3. Nordic life design attitude

The 4-Foci model

Nordic Life Design Attitude works together with the 4-Foci Model, which accentuates the power in changing perspective and reframing. Applying the 4-Foci Model accentuates seeing more perspectives on life issues - could also be a problem, an idea e.g. If a person wants to become a writer or a debater, how can he possibly reframe his ideas in a way that creates value and meaning in a business context? Or for other people? Or in the world? Taking these different perspectives and related questions will help broaden a problem or an idea or even help to identify what and how to act from these different perspectives.

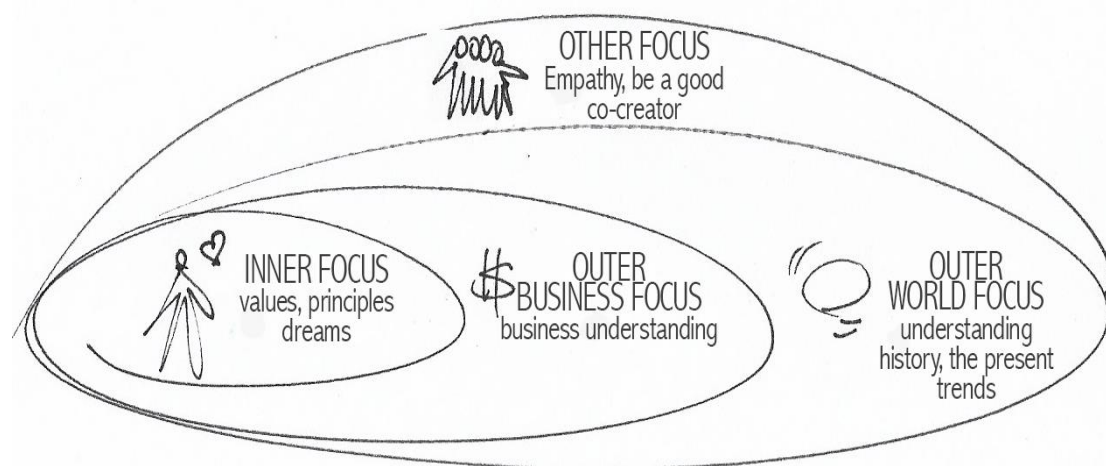


Figure 4. The 4 Foci-Model, (updated version from Sørensen, 2019)

THE 4 FOCI MODEL:

Inner focus - focus on your values and principles, your strengths and weaknesses, what you are curious about, self-care.

Related to inner focus is e.g. knowledge about the brain, body and mind e.g. cognition, creativity.

Outer business focus - how you can transform what you are good at into something that adds value in a business or in the world.

Related to the outer business perspective is basic knowledge about a business, business modelling, value propositions e.g.

Other focus - how to empathize, understand and interact with other people. How to co-create and be a good co-creator.

Related to the other focus is knowledge about empathy mapping, ethnography, user research, how to co-create, community building e.g.

Outside world focus - how to understand the world, your history, the present and sensing the future and changing values and trends

Related to the outer world focus is knowledge about time, history, news.

However, the 4-foci model can be seen as a way of training or creating or even recreating identity - the relation between an inner focus and an outer business focus, another focus or a world focus. Applying the 4-foci model accentuates seeing more perspectives. Also, the precondition for creating a meaningful life, is having a connection between an inner focus and an outer- and another focus. Additionally, having an outer business focus, will strengthen the ability to create a meaningful work life. We know from research in youth that young people have difficulties in sensing themselves. A precondition for the creation of a meaningful life, is that people have a sense of themselves, and can connect to this inner focus.

In particular, young people are training and experimenting with different identities, professional identities, and identities in groups e.g., Yet, in our liquid society, the recreation of identity may also become a general activity in adulthood. Futurists (Skare, 2021) predict we will have more and different periods, maybe including different types of identities: a career pauser, a part-time pensioner, a full-time pensioner or identities that relate to what you like doing, being a writer, a debater, a community helper e.g. Liquid society (Bauman, 2020) appeals to human beings that think more playful about their identity – "we are always in the making" and "I am what I am not yet" to quote Maxine Greene. We ought to see self as a sculpture and each person, young or elderly, is in the process of sculpting his or herself (the inner statue, Jacob (1987). Many students (and adults) are dominated by negative thoughts that disturb and prevent a 'normal' life (David, 2016). Knowledge about how 'identity is never fixed', knowledge about the brains' plasticity and the possibility of rewiring our brains can be both relieving and empowering. Yet, nobody has 'a duty' changing identity; rather it is as a possibility. Working with this 4-foci model accentuates several issues:

- The student needs to identify his/her inner values and principles, understand personal feelings and emotions, which is a precondition for creating value and meaning in life
- The student needs to learn how to reframe something he likes or is good at into something that adds value to a business organization, to other people or the world
- The student needs to learn how to empathize with other people and become a good co-creator to other people and the world. We all are interdependent and co-designers of each other, yet, we also need to be better at creating a higher awareness of co-designing businesses, solutions to problems, democracies, the world and our shared futures.
- The student needs to understand himself/herself as part of a larger community, the outer world. Having insight into the past, the present and training to foreseeing or creating the futures helps the student to contribute and become a good co-creator.

Nordic life design in practice

The following sections will present extracts from different experiments with the Nordic Life Design. As mentioned before, Nordic Life Design has two goals:

1. educating students for life – offering creative life mastery skills and
2. educating students with skills, competencies, and ways of being relevant in a complex and everchanging world – offering a design attitude including design skills and -competencies.

This outline will present five experiments of how to work with this concept in higher education. Depending on the specific course, teachers can choose relevant elements from the framework.

A 7-week course with communication students in Entrepreneurship

In this 7-week course in entrepreneurship the 4-foci model is used as a framework for the whole course. The course starts out presenting the whole framework as well as an introduction to the inner focus, which may seem strange and different. The inner focus is represented in five individual mindset training interventions that runs through the whole course. Each intervention includes a written hand-in and a student-to-student peer-session to follow up on every intervention. Finally, sessions were conducted between student and teacher to examine and discuss the overall impact on the training interventions.

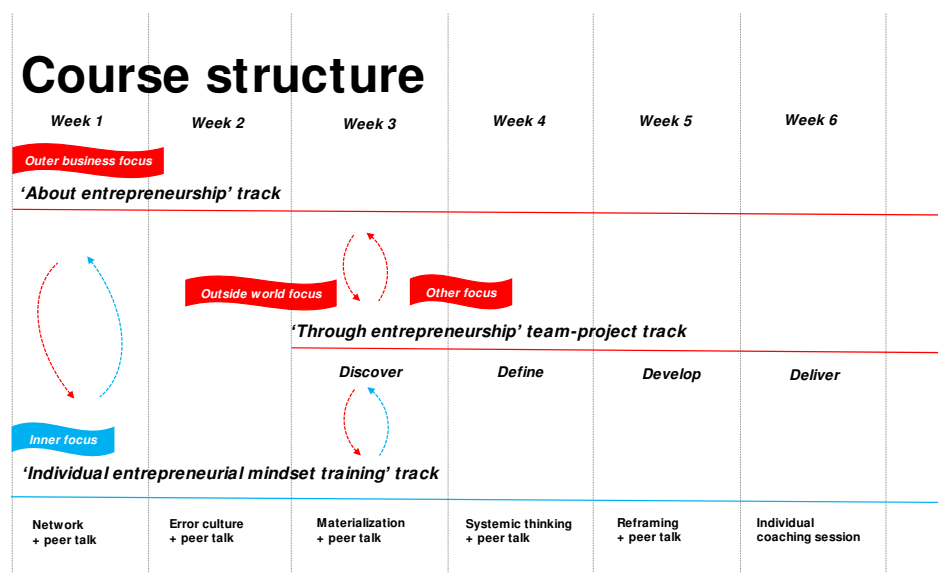


Figure 6. The 4-foci model as a framework for a 7-week course

Sessions were recorded and transcribed. This paper highlights excerpts from the analysis and feedback related to working with the 'inner focus'. However, the students also were working on other elements in the 4-foci, as seen in fig.6. Week 1 introduced to the outer business focus, then followed a design process including working with the outer world focus, like trends and markets and an other focus, like doing user studies. Through the whole course students are presented to the different elements in the Life Design Attitude, and discussing e.g. how to be in a chaotic design process, how to use materialization as a way of understanding issues or building ideas or solutions etc.

The following sections are excerpts from the analysis of the data:

96% of the students find working with the inner focus positive (48 students out of 50). Some students express they find working with an inner focus radical and different from what they are used to:

One student elaborates: "...We have written numerous reflection reports, but I do not think I have reflected that much since we started studying. Even though we are asked to evaluate something, and think about our work process, I think it is something else to have to think of ourselves as persons, and think of our worldview, and the boxes in which we just put things...."

Another student reflects, the tasks inner focus also reflects new or supplemental light on her fundamental understanding of why she is attending school at all "... it just dawned on me one day...I had to hand in the assignments so that I could get something out of it myself. It's for my own sake."

One student reflects: "...these tasks have taught me a lot about breaking the boxes and how I initially

understanding the world, and then break things up and think in new ways..." - applying an even broader understanding, that connects to her understanding and construction of a personal identity.

"Yeah, I think it's been healthy...it is not often that we are given such a free framework in school to decide for ourselves where we want to go. Normally, we get a case, we get a company, we get a problem, we know what to deliver, and then we do that. In our student-job or internship, when faced with a problem, we are sometimes told: 'Just solve it' and at our own control. I think it is very healthy that we get trained in doing just that in school as well..." This students' reflection illustrates education as 'excluded' from real life.'

A 3-day workshop preparing journalism students for internship recommendations

This study describes a new and non-compulsory workshop: "Preparation for Internship," offered to around 100 students at the Danish School of Media and Journalism. Experiences from recent years show that preparing for an internship can be a challenging process. All students apply for an internship, but some years up to 25% of them might be rejected on 'Panic Day', the nick name for the day on which media institutions hire their interns. This process is very stressful to many students, and most students consider not getting an internship as a personal failure.

The intention with the workshop was to help students strengthen their 'inner focus' and their 'outer business focus'. In this way the workshop introduced to Nordic Life Design, but focused only on some elements in the concept.

The intention was building the skills of seeing more perspectives and creating new possibilities. The workshop included activities following Katznelson (2018) recommendations for young students and can be repeated in controlled experiments. The workshop was helpful to some of the students, yet, journalism students do not like talking about themselves and also, they consider creativity to be 'an unserious activity' (Stentoft & Sørensen, 2019). Only 50% of the students completed the workshop.

In the three-day workshop, we offered reflective learning processes. The focus was on working with an inner focus to map, who you are and what you like. Subsequently, the students were working with an outer business focus, trying to combine an inner focus with an outer business focus – for example, by questioning: "How can you transform what you are good at, into something that adds value in a company and/or for other people?" The internship constitutes the entrance to adulthood and a changing labour market that calls for new values and understandings. As Burnett & Evers (2016) point out, people are dominated by 'old' and 'dysfunctional beliefs' like thinking, 'my job is out there waiting for me'. Today, most student will have to create their job (2016). However, people seldom reflect on their values (Sørensen, 2011, Burnett & Evers, 2016). Therefore, some of the assignments were clustered around personal values, both in order to identify their personal values and principles, but also to question some of the dominant values related to concepts such as 'journalist', 'life' and 'success'. Traditionally, in the field of journalism, 'a successful journalist' is working on a national newspaper or nationwide television. In a changing and turbulent media industry, students will have to think more creatively and invent new types of jobs. Likewise, many students think they need to make one plan and then execute it, or they must make the right choice the first time around, otherwise, they will fail.

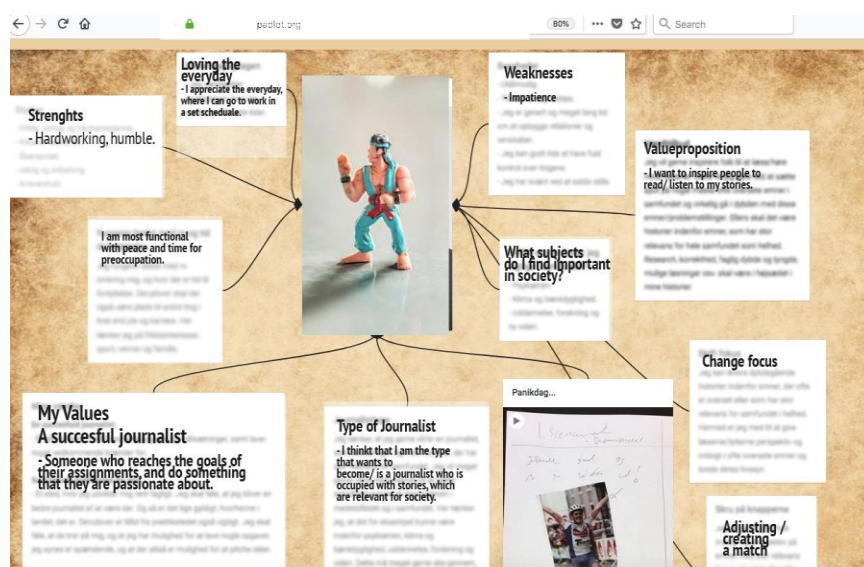


Figure 5. Examples of students' individual PADlets (pictures changed, excerpts of texts)

Some of the assignments included mapping their life journeys and reflecting on their ups and downs, identifying role models or heroes and reflecting on their related characteristics e.g.- assignments that stimulate students to get a stronger sense of themselves. From research we know that students seldom have a sense of themselves; they feel insecure and afraid of not getting on the right track and immediately (Burnett & Evers, 2016, Katznelson, 2018). Moreover, the students were urged to visualize and make a video presentation of three different future scenarios concerning their internship. In this way, they could prepare themselves for all types of scenarios, training themselves to see and create possibilities and reframe potential 'bad' scenarios – and train several of the elements in the life design attitude.

Feedback on the workshop:

In the research, we used mixed methods, combining mixed methods: qualitative and quantitative research methods (Brannen, 2007). Forty students participated in an online questionnaire, and ten students participated in a video interview. The feedback from the students falls into three categories, a) low or no interest/effect b) little/medium interest and c) high interest/effect:

- a) "Spending time cutting, and gluing posters is simply too ridiculous. Call it creativity, reframing, a new mindset or whatever, in my eyes this is not at all useful to prepare for an internship. It's a waste of time and resources."
- b) "In the beginning, it was like 'wow' - I couldn't really relate to it – but when we started working with [the assignments] yesterday, I thought it made a lot more sense, and I got the points about thinking differently [reframing]...." I have experienced reframing my view on other people's expectation of me."
- c) "Many [of the other peers] were very critical of the course, but for me it was very enriching. Many of the tools [teacher's name] mentioned and the things we worked with helped a lot. It gave me more peace and a belief in myself. I was very delighted with the course..."

Design thinking embraces ambiguity and failure as growth opportunities, which often clash with institutional values and structures – and is reflected in student evaluations (Goldman & Kabayadondo, 2016). According to the data, the 4-foci model had a broad appeal: Some students highlight the value of reframing situations or dysfunctional beliefs about themselves. Many are interested in the transformation from an inner to an outer, business perspective. It seemed a manageable challenge to define their value proposition, whereas reframing their inner focus (what they are good at) into an outer, business focus (something that adds meaning and value to an organization) was a harder challenge; few managed this reframing.

Examples of how to incorporate exercises in a current curriculum.

Training divergent thinking, being in ambiguity, chaos, and processes, seeing more perspectives:

As a result of many years of education, (and as seen in our data) students are trained in the strictly defined assignments. Tina Selig (2018) argues that our educational institutions have been practicing strict defined assignments like: $5+5=?$. This type of assignment is training convergent thinking and practice. Instead, we need to offer open defined assignments like: $?+?=10$, that appeal to divergent thinking and practice.

As a teacher, it is relatively easy to reframe an assignment, so it appeals to divergent thinking. Yet, it might challenge both the students (and teachers) – they might feel uncomfortable, losing control and overview. Also, being in the middle of this paradigmatic shift, there is a need for critically to look at 'the hidden curriculum', Henry Giroux's notion describing everything that is being taught in classrooms but not explained in the curriculums - the hidden values, assumptions and mindsets.

Results and implications

Nordic Life Design offers students creative life mastery skills as well as design competencies relevant in a world dominated by change, ambiguity, and complexity. We see possibilities, that the concept might be a possible answer both to the current mental crisis among students and to the need for more updated curriculum in many educational institutions.

In our research, there are certain challenges: First, we have been struggling with narrow understandings of creativity, typically either as 'an unserious activity', or as 'creativity is having many ideas'. Such understandings are barriers to working with Life Design, particularly if you only have a short time. Another challenge is ethical. We are breaking the traditions and working with people's private lives. We argue, the students are not forced to share personal issues, yet, we encourage them to share their experience doing the assignments. In this way we also try to break with the taboo around mental health.

As Siemens (2006) argues, there is a clear tendency in traditional education, that life stops when we learn. From our experiment we can so far conclude that Siemens might be right, there seems to be an obvious need for bringing human life into educations, to have a stronger connection between education and real life (Siemens, 2006) and to reframe essential values and understandings.

Nordic Life Design relates to Bildung, the German word for formation. Bildung involves how learning is integrated into one's own life and one's understanding of oneself. The concept of Bildung has often been used to direct criticism towards an industrial focus on learning objectives, tests and efficiency. Generally, the problem is that the dominating business focus, seeing educational institutions as fabrics that focus on educating students for a market more than educating students for life, leaves students without any knowledge and tools for today's complex life. Instead, educational institutions should take a more holistic perspective and educate students to create quality in life (OECD, Education 2030, 2018).

All in all, we have predominately positive feedback from the students. The idea is to offer the program to all student, as the concept is relevant for everybody, (opposite initiatives that include 'treatment' of the 'weak' students). Also, the intention is, that the program is introduced in the beginning of the education and runs till the end. The program will primarily be individual and digital, yet, there are workshops and talks that highlight human aspects, joys and sorrows that belong to any life. Ideally, parts of the concept are integrated in all courses, to train the various activities and ways of being. In this way, old-fashioned curriculums can be relatively easily updated.

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Different Ideas, Lots of Ideas

A design course that enhances the creative abilities of college students

Jody Nyboer and Brad Hokanson

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This Creative thinking is the ability to generate a wide and detailed range of responses to a given stimulus. It is not a fixed skill; it can be improved through practice. Creative Problem Solving (CPS) is a design course that fosters these abilities. The challenge-based course utilizes a generative learning approach. Students are given a series of assignments that prompt them to 'do some-thing differently' (i.e., eat something different). In their quest towards designing unique solutions, the students are forced to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. The course integrates peer evaluations to encourage originality among the local group and to reveal alternative perspectives. The TTCT is used to measure their creative thinking skills at the beginning and end of the course. Analysing data from nine offerings of the course (n=445) suggests that CPS significantly improves the originality and fluency of student ideas. Considering that these skills are highly desired among the entrant workforce for industries both inside and outside design, a comparable course should be fundamental to the college experience for all students.

Keywords: creative problem solving; creative skills; creative thinking; design, design education

1. Introduction

It isn't a stretch to understand why creative skills are so highly desired. Creative skills are associated with individual attributes such as curiosity, openness to ideas, and willingness to take more risks (Csikszentmihalyi, 2014; Maksic and Pavlovic, 2001; Cecil, Gray and Thornberg, 1995; Torrance, 1988). These skills are also associated with a tolerance for ambiguity (Urban, 2007), and the intuition, perception and insight to think differently about a problem or situation (Turner, 2013; Sternberg and Lubart, 1995; Finke, 1995). What is surprising is that creativity training is not emphasized more or required in college. While creativity courses have increased in popularity (Xu, McDonnell, and Nash, 2005), they have struggled to gain traction as a foundational learning experience that prepares students beyond higher education. The creativity of today's workforce has broad social and economic implications, so knowing how to effectively prepare entrant employees is an important responsibility of colleges.

This article describes the structure and outcomes of Creative Problem Solving (CPS), a design course that aims to foster creative abilities. Pre- and posttest data that was collected from nine different offerings of the course to measure how it improves specific creative abilities of the students. Before presenting the results of this study, this article first outlines the demand for creativity and how higher education fits into the larger picture. Second, it summarizes how creativity is defined and how it is measured. And third, it provides details about the methodology of the course.

2. Invaluable Skill, Essential Training

How one approaches or thinks about solving problems is generally tied to their educational, social, and cultural background. Solving problems can be understood systematically as a back-and-forth exchange of rules, practices, and information between domains, fields, and people, each driven by culture, the environment, and society (Csikszentmihalyi, 2014). However, the typical educational paradigm isn't exactly guided by this



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systematic model. More commonly, students are taught how to solve problems in a high-stakes environment of structured learning which generally entails few exchanges, linear and expected thinking, and standardized assessments. This fosters a learning ecosystem that praises and rewards students on the basis of their ability to 'play by the rules,' and trains them to converge on singular answers and with little feedback from broader contexts. This approach does little to prepare students for the demands of our economic and social future. The contemporary workforce needs and desires people who can employ critical thinking skills and who are capable of generating, exploring, combining, integrating, and defining new ideas. Currently, entrants into the workforce lack creativity and innovation, the two very attributes that are argued as essential for success (Casner-Lotto and Barrington, 2006). And this is not isolated to industries and markets that are epitomized as 'creative' such as design and art. The need for creativity extends to sectors of public policy (Pattnaik and Banerjee, 2020), business, economics and law (Urquia-Grande and Estébanez, 2020), business informatics (Martz, Hughes, and Braun, 2017), chemistry (Hill et al., 2019), and tourism and hospitality (Trajanoska and Kostovski, 2016). Puccio and Cabra (2010) suggest that organizations lack creative individuals, creative processes, and the environmental attributes that engage employee creativity, and that without these attributes are less likely to produce internal and external innovation. Simply put, the deficiency makes it less likely that an organization will thrive.

Carnevale and Smith (2013) suggest the post-industrial era has resulted in "fundamental changes in the skill requirements of the US economic system," creating pressures to place a premium on "problem-solving and creative thinking... at all levels of an organization " (p. 493; 495). Thus, if college students want to be "competitive, attract the right type of industry, and engage in the right type of talent in the new knowledge economy" (p. 497), they must learn how to think logically, employ critical thinking skills, generate new ideas, explore ideas, and combine, integrate, and reinvent the way they think. Students must also compete with computerization which is best countered if they can foster the skills that computers lack; creative and social intelligence (Frey and Osborne, 2017).

Puccio (2017) argues that creativity is a crucial survival skill for the 21st Century, and that meeting the demands of tomorrow are the responsibility of higher education. Puccio suggests that colleges thus far have played a problematic role by promoting a culture of 'conformity' rather than one of creativity. This has created serious consequences for our economic and social future. And the gap between higher education and industry has not gone unnoticed by employers. Urquia-Grande and Estébanez (2020) suggest that creativity and cognitive skills are grossly lacking in today's entrants who are hired right out of college and recommend that academic advisors prioritize guiding students toward training that ensures that they are adaptable to and prepared for the 'real world.'

Fostering the capabilities that are needed to address global change lies within curricula (Mosier and Kaiser, 2019; Drake and Reid, 2018), and that it should be prioritized early in a student's path towards a degree (Martz, Hughes, and Braun, 2017). When this emphasis is lacking, students miss a key aspect of how they might compete for employment. For example, Hill et al (2019) found that chemistry majors struggle to understand that prospective employers want entrants to have transferable skills beyond their discipline, and that such skills could actually improve a student's success in competing for jobs. They summarize, "it is not clear whether students recognize the development of these skills or understand their importance. Without such recognition of skill development, it could be argued that academics' efforts to incorporate them into their courses are, at least to some extent, wasted."

The world is rapidly changing, and the mission of the industrial world is constantly being transformed. Thus, students need transferable skills that go beyond their degree programs so they can be relevant and change agents in their field(s). Industries desire creative entrants, but they also report that these attributes are horribly lacking. While higher education is not the sole culprit, this deficiency can be addressed by providing students with opportunities to engage in a conscious process of *unlearning* the structured protocols from standardized paradigms of learning. However, this article contends that more aggressive measures are needed. Colleges should require students to take courses that train them to be voracious ideators and visionaries and cultivate their creative abilities.

3. Cultivating Creative Abilities

Researchers who study creativity and learning often asked how they measure it. This isn't surprising, as creativity is widely regarded as subjective (Haynes and Martens, 2011). As a descriptive word, creativity is often used in as a judgment of value, weighted against cultural and social contexts and norms. For this reason, calling something or someone creative may be resonant to one group but not another. Creativity is also a term that is broadly applied, yet not wholly defined for mainstream use. Glăveanu (2016) suggests that the

uncertain and broad use of the word devalues its meaning. This makes it difficult for people to conceptualize creativity as something that has quantifiable dimensions. Runco (2014) suggests that some of these complexities can be addressed by using the word as an adjective rather than a noun (i.e., creative thinking, creative process, creative product). Once the word 'creative' is applied to something discernible it becomes easier to understand how it can be defined and measured.

So, what does it mean to be a creative person? The literature suggests that they have a "special kind of human potential or aptitude." (Urban, 2007, p. 168). Creative people produce novel ideas which are uniquely appropriate for solving a problem (Sternberg, 1999). Creative people *create* (Hasirci & Demirkan, 2007), but what they create is *different* (Glăveanu, 2016; Runco, 2014). While these ideas about creative people shed some light on defining the attributes of a creative person, perhaps the most agreed understandings that the creativity of a person is objectively about *thinking*.

Over 60 years ago, Guilford (1957) suggested divergent thinking as essential to creative ability, and involving four major dimensions: originality, fluency, flexibility, and elaboration. Originality is the ability to come up with unusual or different ideas. Fluency is the ability to come up with lots of ideas. Flexibility is the ability to perceive alternative perspectives concerning an idea. Finally, elaboration is the ability to add details to ideas that enrich their meaning. Torrance (1988) used the four dimensions to develop the Torrance Test of Creative Thinking (TTCT). Today, the TTCT is the most widely used instrument for measuring creative thinking (Starko, 2013; Kim, 2006; Cropley, 2000). Psychometrically, the TTCT is reputable for its reliability and predictability validity (Starko, 2013; Althuisen, Wierenga & Rossiter, 2010; Kim, 2006; Cramond et al., 2005; Cropley, 2000). The process of arriving at novel ideas typically involves iterating (Brennen, 2015; Feldman, 1999; Amabile, 1983). A creative process can be described as the operations that must be performed to result in a creative outcome or product. Engaging in activities that develop an idea in this way involves thinking and decision making which can be influenced by motivation, inspiration and perspective (Rhodes, 1987). Divergent thinking has long been regarded as the integral agent of any process that results in creative outcomes (Torrance, 1988). However, contemporary research suggests that convergent thinking also plays an important role in both generating and developing ideas (Cropley, 2006).

Wallas' Four Stages of the Creative Process (1976) is perhaps the most widely used (and adapted) model for explaining what a creative process looks like. The model suggests that creative process as a dynamic procedure collecting knowledge and allowing that knowledge to incubate. As ideas begin to form, the consideration for multiple perspectives and a myriad of possibilities allows one to synthesize the knowledge into something that can be presented to and judged by others. Usually this leads to re-entering a process of collecting, incubating, and synthesizing additional information and continues until a suitable solution or appropriate idea is defined. For architecture, this may be a school design. For product design, it may be an ergonomic device for the elderly.

The outcome of the process described above is generally regarded as 'creative' if it is unique, effective, or useful (Runco and Jaeger, 2012; Plucker, Beghetto and Dow, 2004). However, such criteria are often contextually dependent, especially in an organizational setting (Haynes and Martens, 2011, Reiter-Palmon, 2011). For instance, Barnard (2005) calls creativity for graphic design a 'cultural' production.

Evaluating the creativity of outcomes is often swayed by misconceptions. For instance, creative outcomes are often assumed to be physical artifacts. Even Rhodes (1987) suggests this, defining a creative product as a record of an idea that has manifested into a tangible form. However, a creative product can be more than something that you can touch; it can be an action or a behavior, an imaginative or playful approach to solving a problem, or a concrete object or idea (Runco, 2014; Mayer, 1999). As another example, particular activities and talents (such as art) are widely considered to have a claim on creative outcomes (Halpern, 2003). However, in reality anyone is capable of generating a creative product (Kaufman and Beghetto, 2009).

Teaching and researching in the field of creativity has fostered a broad understanding of this topic. Assessing the creativity of people, processes, and things is both imaginable and achievable. Evaluating the creativity of the exploratory steps (process) that one takes to move towards a solution is arguably the hardest to quantify. However, measuring creative skill (thinking) is fairly straightforward. Creative thinking is flexible; it can be developed through exercises and practice (Felsman, Gunawardena and Seifert, 2020; Scott, Leritz, and Mumford, 2004), and it can be taught (Hokanson, 2007). In other words, students can be trained to think more originally, to improve their fluency of ideas, to develop the ability to engage multiple viewpoints, and to develop details that enrich an idea.

So, what are the challenges of training college students, besides lacking curricula to do so? Johnson and Jablonsky (2019) suggest that the students themselves could be a challenge; their cultural backgrounds have a strong influence on how they perceive creativity. However, their research suggests that creativity-related learning experiences that are carefully designed can intercept apathetic perceptions of creative abilities and

actually enhance student performance of these skills. Similarly, Chen and Yu-Jung (2019) suggests that students productive potential can be liberated through training, particularly by increasing their *innovative* creativity, which is the ability to produce new ideas that do not necessarily align with an existing cultural paradigm.

The stakes are high for overcoming the barriers and providing students with opportunities to enhance their creative thinking skills. Those who receive creativity training in college are more attractive to employers, but also benefit from the lasting effects of their enhanced skills (Martz, Hughes, and Braun, 2017; Im, Hokanson and Johnson, 2015; Scott, Leritz, and Mumford, 2004). Simply put, providing students with creativity training makes them more intent on *behaving* in an innovative way (Hidayat, 2019), and that is likely to enhance their experiences in ways beyond academics and employment.

The next section describes a design course driven by the notion of ‘different’ that provides creativity training for college students and results in enhancing their creative abilities.

4. Designed Around Different, Designed for Change

Creative Problem Solving (CPS) is a design course that is designed to foster creative abilities. The essential primer for course is ‘do something different’ (DSD), facilitated through a series of challenge-based assignments (i.e., eat something different). The DSD method is fitting for a couple reasons. First, in their quest towards designing unique solutions, the students are forced to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. This facilitates a more meaningful experience while helping students understand the role of creativity and innovation in their own work and in other disciplines. The course also integrates peer evaluations to encourage originality among the local group and to reveal alternative perspectives. Second, just simply asking a student to generate a solution that is different is shown to foster more creative outcomes (Mumford et al., 2020).

The broader goal of the course is to create lasting, permanent, and integrated connections between the student’s personal life, their own creativity, and their field(s) of study. Thus, CPS is grounded in a generative approach to learning which encourages the students to be the author of their explorations. This approach is believed to foster creative skills that are more eminent (Yang and Cheng, 2010). The generative explorations challenge students to identify and change their own cultural, habitual, and normal patterns of behavior and also to appreciate the relationship of these variables to individual creativity. DSDs allow students to develop creative ability, but also encourage them to understand creativity as a social and cultural construct. For instance, if they are challenged to ‘eat different,’ they must first consider how norms influence what and how they (or others) usually eat, and also how those influences limit their ability to conceptualize novel solutions. This process typically challenges them to also deconstruct the concept of focus. For instance, what does eat mean, or does it mean to eat?

As a means to break free from normative practices to arrive at something truly new, the course structure consistently guides them through strategies that allow the students to both practice and apply their creative abilities. The students establish that there are a ridiculous number of possibilities (fluency), are pushed to approach and define the simple problem in unusual ways (originality), consider a wide range of perspectives that go beyond just understanding and experience of the topic (flexibility), and to embellish their ideas with a range of details that change or enhance the meaning of topic (elaboration).

Developing ideas that are truly unique and new require students to think beyond immediate or familiar contexts. CPS is built around the assumption that student behavior, habits and thinking are largely paralyzed by cultural, social, and personal norms. While an individual may be regarded as ‘creative,’ it may be because they live within a society or family that has particular limits. Thus, it is important that the students are guided to define, analyze, question, and deconstruct the contexts that define normal practices and circumstances as they approach the DSD challenges. And because ‘different’ is subject to what one knows or understands, the students must convey their exploration and outcomes to others for peer review and in-class discourse.

Creativity in CPS means debuting an idea to a world beyond a closed ecosystem of immediate experiences and knowledge; students are required to complete most of their assignments within the public sphere to fully engage in a rich exploration that engages others. The resulting explorations are often wild, eye-opening adventures. They can be both funny and serious, which means that they can also take people by surprise. In some extreme instances, the presentation of a DSD might require a trigger warning. That said, the explorations do have imitations. DSDs are limited by health, safety, legal, and economic concerns that protect the students and others. But these limitations also implore design constraints that are important for fostering creative thought and actions (Beghetto, 2019), and making the creative process less intimidating for students (Mumford et al., 2020).

Examples of the DSDs are difficult to capture in a paper as they are submitted as video files. However, stills from the videos and student reflections are able to depict the rich nature of the studies and the potential each DSD has to be a transformative learning experience. Figure 1 shows an exploration from DSD Take, in which one student reflected on the contemporary relevance of a primitive idea: taking from the environment. The student developed their idea into a field experience of collecting what they could forage from their immediate neighborhood and considering its usefulness to someone in need. They shared the following reflection:

This does point to how difficult it is to be a person... you know, if you do not have capital (social or otherwise). You still have to live like a human would have lived back many years ago but without the capability to trade with another person or to receive a gift from another person. You're basically left foraging in your environment which is impossible to do... you can't survive on your own without another person without taking something.



Figure 3. Snapshots from the result of one student's DSD Take in which they reflect on contemporary relevance of a primitive idea: taking from the environment.

Another example that demonstrates the interpretive potential of the challenges is from DSD Make where a student gathered their friends for an unusual 'making' activity with clay (see Figure 2a). She challenged them to form the clay into difficult concepts to depict such as wealth, beauty, and fear and then talk through the meaning of their creations. The peers who reviewed this DSD reflected on its power to reveal insight about those you think you already know, and its potential as a therapy activity and unique conversation starter.



Figure 2. a) Stills from the result of one student's DSD Break in which they challenged their friends an impossible task: to 'make' things that cannot really be made out of clay such as wealth, beauty, and fear (left). b) Stills from a student's exploration interviewing people with questions that relate to the work of a parent (right).

Students often develop the DSDs into opportunities for drawing public awareness to an issue or concept. The example in Figure 2b shows a student who used the DSD Break challenge to interview strangers about work conditions. The participants did not know that the questions related directly to the work of a parent. Some questions included, "Would you work for 24 hours, seven days a week for free?" and, "Would you work in a job where the number of team members increase but instead of decreasing the stress of having more people to help you work, it would actually increase the stress?" and, "Would you continue to do a job if there were no upper mobility in the company or opportunity for promotion?" After revealing that they were describing a parent's work, she then asked her participants if they felt that parents needed a break. This yielded surprising

reactions from the participants (some of whom immediately after called their parents) and rich discussions. In their reflection the student wrote, “Millions of people perform these jobs that no one wants to do in this interview. They do it for free because of love, care, and support. They need a break!”

Creative Problem Solving also challenges students to apply their training to collaborate on a cross-disciplinary project. The projects range from developing elaborate material-functional designs such as Rube Goldberg machines to design interventions for wicked problems. Recent projects from the latter include the Consumption Clock which is an analog proposal for intercepting excessive use of social media, the vFume smartphone plug-in device which allows consumers to detect VOCs in textiles, and The Curve which suggests a design and access system for pop-up bio hubs on college campuses to support the mental health of students (see Figure 3). These projects demonstrate how the DSDs provide the preparation that students need to realize their potential as change agents.

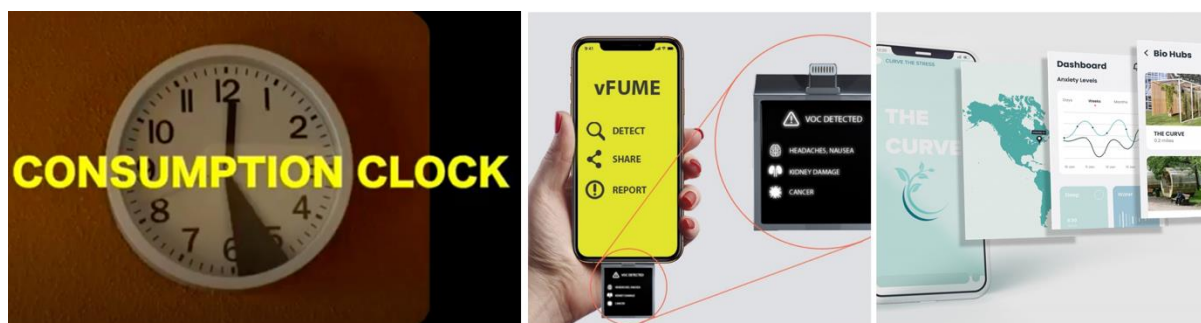


Figure 3. The Consumption Clock (left), the vFume (middle), and The Curve (right).

Generating new ideas is a skill that can be used to develop a project of any type or size, but it must be developed through *practice*. Practice requires willingness to broaden how one thinks; to question norms, to reexamining habits, to encourage and embrace unique viewpoints, to value the findings that emerge from individual explorations, and to take risks to express ideas beyond personal bubbles. Dedicated practice increases students' aptitude and frequency to engage in divergent thinking and to develop original ideas. Therefore, in addition to the practice that students receive from the DSD challenges, the course also introduces students to classic and new techniques for creative practice and has students exercise these techniques in class daily.

5. Analysis of Nine Courses

Creative Problem-Solving (CPS) is designed to improve the creative abilities of students. Thus, the course utilizes instrumentation to measure the creative ability of students at the beginning *and* end of the course. The Torrance Test of Creative Thinking (TTCT; Torrance, 1988) has been the primary method of assessment to evaluate the success of the course for all offerings between 2014 and 2019 and has been important for substantiating the value of the course to learners. The following section presents the findings that emerged by analysing the data from nine different offerings of the course.

5.1. Description of Sample

The data for this study was collected from students who were enrolled in nine different CPS courses between 2016 and 2019, yielding a large sample size ($n=445$). The nine courses were taught by two instructors who co-designed the course, and thus approached teaching it with the same structure and methodology. The creative ability of the students in all nine courses were assessed at the beginning and end of the course using the TTC. The TTCT was professionally scored by the Scholastic Testing Service Incorporated (the instrument's publisher), providing a high level of reliability. The TTCT score reports include individual scores for performance and provide comparisons to standard scores, and rankings among the national percentile for grade (college) and local percentile (class cohort). The reports also include attributes of the students such as age and gender. There are two versions of the TTCT available: verbal and figural. The verbal version is a series of six exercises that spur written responses in periods of five to ten minutes, and it measures three dimensions: originality, fluency, and flexibility. The figural version is a series of three exercises that implore drawing, each completed in ten minutes for a total test of thirty minutes. It measures five dimensions: originality, fluency, elaboration, titles, and resistance to premature closure (shortened in this article as 'closure'). Since 2014, both have been used among the two instructors of the course at their discretion. Three of the nine courses analyzed in this

study (n=124) used the *figural* version to measure the change in ability and the remaining three courses used the *verbal* version (n=321). Utilizing both versions limited the dimensions that could be analyzed across the entire sample. The two common measurements between the two versions are limited to originality and fluency.

Creative Problem-Solving has collected sufficient data to analyze how the design course has impacted the skills of the students. The analysis below substantiates how the abilities of students increased after taking the course. The sample is analyzed as a whole and also individually for each of the nine courses.

5.2. Distribution of Standard Scores for the Entire Sample

The creative abilities of students increase after taking Creative Problem-Solving. This is evidenced by the distribution of standard scores for the entire sample which indicate that fewer students have low scores after taking the course. Figure 4 illustrates the distribution of scores for test A (pre-test) and test B (posttest) for the dimensions of fluency, originality, flexibility, elaboration, titles, and closure. The plots do not capture data about students who experienced lower scores after taking the course. Thus, statistical analyses in the following sections are necessary to establish the statistical significance of these changes.

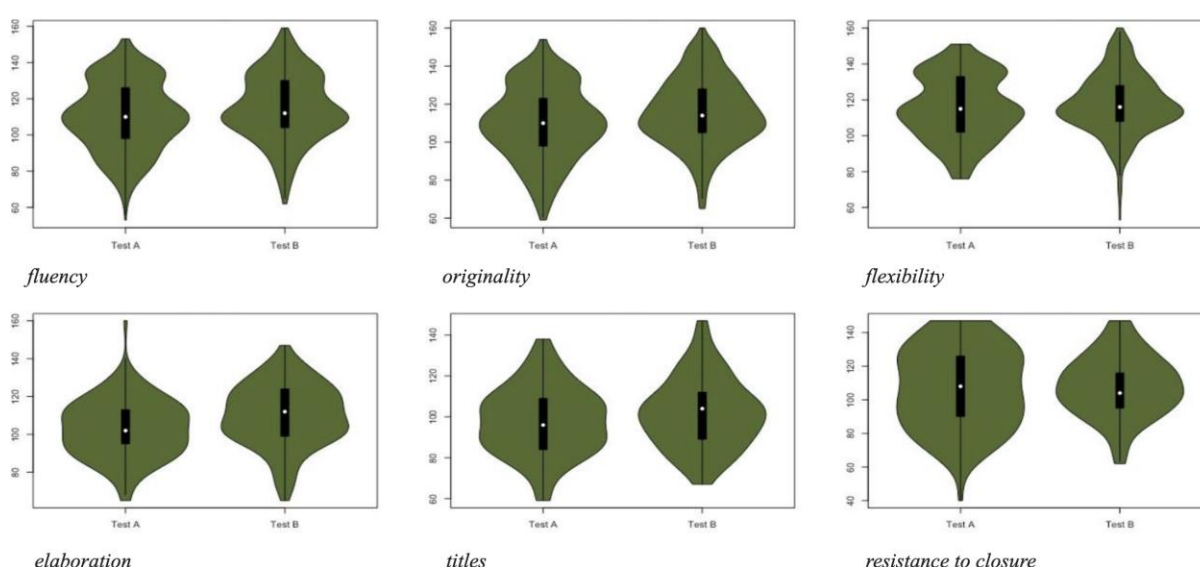


Figure 4. Distribution of standard scores for six dimensions of creative ability after taking CPS.

5.3. Significant Changes in the Standard Score and National Percentile for Each Course

The verbal TTCT assessed the changes for six of the courses and the figural version assessed the other three. The versions differ slightly. The verbal test measures originality, fluency, and flexibility, and the figural test measures originality, fluency, elaboration, titles, and closure. Most of the classes were in-person, but three were online (an attribute that is not explored in this particular study). Performing paired t-tests reveal the significance of changes in standard scores (Table 1) and national percentile (Table 2) for each individual course. The data demonstrates that there are significant increases in particular dimensions of creative abilities across courses.

The analysis of each individual course suggests conclusions about the learning gains from the course, but also reveal potential discrepancies among the different versions of the TTCT. First, the standard score and national percentile of originality for students in the in-person class increases with 95%+ certainty, despite which TTCT version is used to test the change. Second, the standard scores and national percentile for fluency increase with 99% certainty for the in-person courses, but for only those that use the verbal TTCT to assess the change. Some additional thematic gains are identified in each version of the TTCT. The verbal TTCT indicates a pattern of increased standard scores for flexibility (95% certainty). And the figural TTCT indicates a pattern of increased standard scores and national percentile for titles (99% certainty) and a pattern of increased standard scores for closure (with 95%+ confidence).

There are limitations to what can be learned from the above analysis. In statistics, sample size is important for determining correlations. This study aims to know if there is statistical significance to the gains in ability that are measured from taking Creative Problem Solving. For this reason, the final analysis clusters the TTCT data together to perform paired t-tests. The final analysis resolves if the changes are in fact significant for the

population of students who have taken the course.

Table 1. Significance of changes in the standard score for each course in Creative Problem Solving.

TTCT	Year	Dimension	Decrease	Unsure	Increase (% confidence)		
					90%	95%	99%
Verbal	2016	<i>fluency</i>					x
		<i>originality</i>					x
		<i>flexibility</i>				x	
	2017	<i>fluency</i>					x
		<i>originality</i>					x
		<i>flexibility</i>				x	
	2017 ^{OL}	<i>fluency</i>		x			
		<i>originality</i>		x			
		<i>flexibility</i>		x			
	2018	<i>fluency</i>					x
		<i>originality</i>			x		
		<i>flexibility</i>					x
	2019	<i>fluency</i>					x
		<i>originality</i>				x	
		<i>flexibility</i>				x	
	2019 ^{OL}	<i>fluency</i>	x				
		<i>originality</i>	x				
		<i>flexibility</i>	x				
Figural	2018	<i>fluency</i>				x	
		<i>originality</i>					x
		<i>elaboration</i>		x			
		<i>titles</i>					x
		<i>closure</i>					x
	2018 ^{OL}	<i>fluency</i>					x
		<i>originality</i>					x
		<i>elaboration</i>					x
		<i>titles</i>				x	
		<i>closure</i>				x	
	2019	<i>fluency</i>		x			
		<i>originality</i>					x
		<i>elaboration</i>		x			
		<i>titles</i>					x
		<i>closure</i>				x	

^{OL} online course

Table2. Significance of changes in the national percentile for each course in Creative Problem Solving.

TTCT	Year	Dimension	Decrease	Unsure	Increase (% confidence)		
					90%	95%	99%
Verbal	2016	<i>fluency</i>					x
		<i>originality</i>					x
		<i>flexibility</i>				x	
	2017	<i>fluency</i>					x
		<i>originality</i>					x
		<i>flexibility</i>					x
	2017 ^{OL}	<i>fluency</i>		x			
		<i>originality</i>		x			
		<i>flexibility</i>			x		
	2018	<i>fluency</i>					x
		<i>originality</i>				x	
		<i>flexibility</i>					x
	2019	<i>fluency</i>					x
		<i>originality</i>					x
		<i>flexibility</i>		x			
	2019 ^{OL}	<i>fluency</i>	x				
		<i>originality</i>	x				
		<i>flexibility</i>	x				
Figural	2018	<i>fluency</i>			x		
		<i>originality</i>					x
		<i>elaboration</i>		x			
		<i>titles</i>					x
		<i>closure</i>				x	
	2018 ^{OL}	<i>fluency</i>					x
		<i>originality</i>					x
		<i>elaboration</i>					x
		<i>titles</i>				x	
		<i>closure</i>		x			
	2019	<i>fluency</i>		x			
		<i>originality</i>					x
		<i>elaboration</i>		x			
		<i>titles</i>					x
		<i>closure</i>				x	

^{OL} online course

5.4. Significant Changes in the Standard Scores for the Entire Sample

Paired t-tests of the standard score for each dimension determine if there are significant increases or decreases in creative ability after taking the course, or if the changes are statistically uncertain. The level of significance is often expressed as a p-value between 0 and 1. The smaller the p-value, the stronger the evidence that the x variable can influence the y variable. For the purpose and hypotheses of this study, a low p-value ($p \leq 0.05$) indicates statistically significant evidence that the course results in increasing the creative

ability of students. The results are summarized in Table 3.

Table 3. The results of paired t-test modeling to determine if the increase in standard scores for six dimensions of creative ability is significant after taking Creative Problem Solving (when the alternative hypothesis is that the true difference in mean is not equal to 0).

Dimension	p-value	conclusion
Fluency	5.39e-08 ^a	increase
Originality	9.598e-12 ^a	increase
Flexibility	0.0195 ^b	<i>increase</i>
Elaboration	1.419e-05 ^a	increase
Titles	0.05585	can't be sure
Closure	0.522	can't be sure

Significance codes: ^a $p < .001$ ^b $p < .05$

The changes in all dimensions of creative ability (except one) are significant. The standard scores for fluency and originality ($n=445$), and elaboration ($n=124$) increase with 99% certainty after taking the course. The standard scores for flexibility ($n=321$) increase with 95% certainty. The standard scores in titles ($n=124$) increase with 90% certainty after taking the course. On the other hand, there is no statistical evidence that the course results in an increase or decrease in standard scores for closure; it is uncertain that the course influences this dimension.

5.5. Summary of Analysis

Three analyses confirm that students who take Creative Problem-Solving experience increases in creative ability. Depending on the inquiry asked of the data, different conclusions are drawn. When the entire sample is modeled to simply show the before and after distribution of scores, it is visually and mathematically resolute that the standard scores for all dimensions are increased; there are fewer low scores at the end of the course than there are at the beginning. However, this method has limitations; because the data is grouped as a whole it does not reflect the individual circumstances in which scores were worsened. As a means to address the role of individual scores, two additional steps of analysis are explored.

As an initial extensive analysis, changes in the six dimensions of creative ability are examined for each individual course. The analysis reveals thematic gains per course, particularly for those that are taught in-person. The increase in standard scores and national percentile of originality and fluency of students who take the course is significant. For fluency, the data is more suggestive when the changes per dimensions are measured using the verbal TTCT. However, the gains in originality are consistent across both versions of the test. The analysis of the individual courses reveals other themes as well; the standard scores for flexibility increase for the majority of the courses as well as the standard scores and national percentile for both titles and closure. The evidence does not suggest that changes in elaboration are thematically significant when comparing the individual courses.

The nine courses were offered independently, at different times and from different instructors. However, when the standard scores for each of the six dimensions are combined (as if every student is taking the same course at the same time) it suggests that the increases in the scores for fluency, originality, and elaboration are the *notably* significant (with 99% certainty or $p < .001$) and that flexibility increases are significant (with 95% certainty or $p < .05$). While the analysis suggests that the scores for titles increase, the certainty is just shy of the typical threshold ($p \leq 0.05$).

In summary, the most significant gains from taking the course are evidenced by increases of originality and fluency. Creative Problem-Solving improves a student's ability to come up with different ideas, and a lot of ideas. The results and their limitations are discussed below.

6. Discussion

6.1. Creative Problem-Solving Increases Fluency and Originality

The results presented in this article suggest that the creative abilities of students are significantly increased by taking Creative Problem Solving (CPS). The course specifically increases student originality and fluency of ideas.

This is consistent with other researchers, especially those who have implemented unique teaching methodologies that foster exercising particular dimensions of thinking. Felsman, Gunawardena and Seifert (2020) found that regular improvisation exercises result in “relative gains in fluency... and originality.” (p. 6). And this is fantastic for college students as the benefits go beyond college. The increased skills make them more likely to execute creative processes in their work and will also make them more likely to use the critique of their work (and their errors) as a launchpad for improvement (Mumford et al., 2020). Also, improved fluency increases the chance that students will arrive at more novel answers (Dippo and Kudrowitz, 2013). This is exactly what the workforce needs.

6.2. Successful Aspects of the Design Course

It is important to point out that this article does not present evidence for *why* Creative Problem-Solving (CPS) successfully enhances the creative ability of students. Based on the review of related literature, one might assume that the success relates to repeat exposure to creative thinking strategies and exercises. Indeed, the students practice a variety of thinking strategies as warm-up exercises at the beginning of each class. However, these opportunities are limited to intermittent course sessions twice a week. Perhaps there is something more about the design course that encourages students to avidly engage their creative skills training beyond the scope of classwork. Or, perhaps there is something about the assignments that encourage students to diligently engage an iterative process of working towards a solution, providing more opportunities to practice and develop fluency, originality, flexibility, and elaboration.

The ‘do something different’ challenges are the heart of the course, and they have distinct characteristics that might explain why methodologically they are especially fitting for creativity training. These characteristics are further discussed below. These are discussed below.

Defining the nature of a problem can impact whether or not a problem solver arrives at a creative solution. Some problem solvers may not even understand that a problem *warrants* a creative solution. Therefore, merely suggesting that particular problem is a creative opportunity will improve the chance of a creative solution (Mumford et al., 2020). This is a key characteristic of the Do Something Different challenges. As the name applies, the DSDs prompt students to strive for something new, unique, and novel. The sheer name of the challenge is a primer for students to realize that there is an opportunity to develop something new and novel, either for others or for themselves. And this is true even though the DSD challenges are extremely simple.

Constraints are commonly mis-represented to limit one’s creativity. It is true that creative work can be squelched when constraints are too controlling or too numerous (Glăveanu et al., 2019). However, constraints can provide valuable support when there is also a tolerance for unplanned learning moments. The creative thinking and actions of students are facilitated when students can engage with a level of ‘structured uncertainty’ (Beghetto, 2019, p. 34) as they navigate guiding constraints. Allowing students to engage productively with this uncertainty requires instructors to resist predetermining four elements of a task: problem, process, outcome, and criteria of a task. The DSDs set general criteria for students so they know what is expected of them. For instance, one criterion is that students identify and challenge the norms and cognitive biases that are limiting their DSD, as this is shown to improve the quality of creative solutions (Todd et al., 2019). Also, the students are provided workshops that teach them a wide range of ideation strategies. Though students are not required to implement specific strategies, they are encouraged to use them to engage a richer process but not to control it. However, defining the problem, cultivating the idea, designing how the idea will be put into action, and analysing the meaning behind the explorations are left completely open for the students to develop. In this way, the DSDs are designed as unplanned lessons that “remove the ceiling” of possibilities for what students might do (Beghetto, 2019, p. 36).

To some students, the DSD challenges are laughably simple (i.e., eat different). However, the simple problems are familiar, approachable, and non-intimidating and allow the students to successfully identify and explore a breath of contexts that surround them (both in and outside of their own domains and norms). In turn, defining the complexities and constraints as a means to develop their work become tangible and even rewarding practices that the students wholeheartedly engage in. And placing themselves into the problem and defining its contextual meaning and perspective (self and other) make each DSDs a ‘sociocultural act’ which elevates the connection between their learning and creativity (Glăveanu, 2015). Some might argue that these sociocultural acts are the heart of generative learning. Hokanson and Nyboer (2017) summarize that generative learning is key to a creative problem-solving course because “making and creating solutions involves learners cognitively and deeply.”

A student will understandably label a DSD challenge as ‘boring’ if they lack investment or interest in it, and they may feel unmotivated to devise an exciting solution if they are that disengaged. Life experiences suggest

that this is a logical concept. However, research supports this as well. Investment Theory (Sternberg and Lubart, 1995) suggests that creativity is driven by a deep, personal degree of motivation. Kaufman and Beghetto define creativity as a special type of creativity among the 4C model. Dubbed as 'mini-c,' these creative acts involve personally meaningful experiences or those that are personally novel. The relationship of mini-c to even online creative problem-solving courses with DSD challenges is observable. By interviewing students enrolled in the massive, international online version of this course, Lawrence and Hokanson (2016) found that the students related personal understandings to the development of their DSD solutions which lead to experiences they described as 'life-changing' beyond the scope of ordinary student learning outcomes. The DSDs prime students to be invested by encouraging autonomous, creative adventures that reflect on personal experiences and knowledge. And the students are prompted to question the role that those experiences have in channeling particular constructs of their behavior and thinking. This keeps them engaged, and it likely keeps them actively ideating and elaborating (and thus avidly exercising skills that increase their creative ability). Research suggests that creativity is eminent when students are affirmed of their creative abilities but also when they are the authors of their own ideas and solutions (Yang and Cheng, 2010). And Mumford et al. (2020) suggest that when people reflect on past experience it results in more creative problem solutions. These are essential attributes of the CPS course methodology. Students are asked to take a simple idea, to consider their relationship with the context, to define the norms that control or appropriate what usually happens, to ask what should happen, and to embrace an exploration that moves outside of the paradigm they know.

Several design courses may do all of the things outlined above. Surly, instructors from all disciplines ask students to reframe problems and question the contexts that surround ideas. However, the course evaluations associated with this class suggest that Creative Problem Solving is a unique course that is not easy compared to others (both within and outside of design), and that students attribute the gains they made in their creative abilities to the personal connections they made with their design solutions. Some students describe the DSDs as the most unusual assignments they have in college, and that often the challenges didn't feel like something that they could get credit for in school. Other students describe them as engaging and fun, and others as serious and deeply meaningful. Others describe the DSDs as the most important experiences they had as learners, that they wish they could take the course again, and that all students should take it too. And consistently, students shared how the course changed their life in surprising ways.

6.3. Limitations

The size of this study is favorable for performing analyses that conclude how the Creative Problem-Solving enhances the thinking abilities of learners. While there are limitations that may influence the results, they present opportunities to inspire exciting and important future studies.

First, the nine courses analyzed in this study are taught by two instructors at two different institutions who vary in teaching experience and general demographics (age, gender, etc.). While the two instructors approach teaching CPS in the same way and use the same protocols and methods, it cannot be ignored that instruction matters -- Who teaches, how they teach, where they teach, and unique dynamics of how one interacts or communicates with students.

Second, the courses vary in delivery. Three of the nine are online which means that the peer review experiences, daily exercises, and discussions are administered in a digital, primarily asynchronous environment. The online courses meet twice in person; at the beginning and the end of the course to take the TTCT. The courses protocols and methods are identical to the in-person course, but it is well documented that online instruction is perceived differently by students who crave social, in-person interactions. Students who felt disengaged because of the online delivery may have had an impact on their engagement with the course challenges and peer reviews. This might explain the disparity of results observed in Tables 1 and 2; in one case the creative ability in all dimensions measured decreased after taking the course. This is an area for further study; how does the delivery of the course influence the ability gains that correlate with the course.

Third, the version of the TTCT vary from course to course. This variance is the results of choosing one test of the other due to funding (one version is considerably less expensive), but also the choice to use the figural for populations that have more international students (to eliminate language barriers). Because the versions varied, this means that four of the dimensions (flexibility, elaboration, titles and closure) are impossible to statistically model across the *entire* sample of data. The large sample size of n=445 is beneficial for analysing the dimensions that are common to both versions of the test: originality and fluency. Future studies might expand the sample size to discover other additional conclusions about the other dimensions. Also, future studies might consider using one version of the TTCT.

Fourth, this study concludes that fluency and originality significantly increase after taking the course. However,

this study does not control the influence that other academic experiences and life in general have on students. It is possible that influencing factors beyond this course are related to the increase in these two abilities. Finally, performing a regression analysis to determine the attributes that influence the gains in ability would be a powerful extension of this research. International status of students, a student's year of study, and even the peer review scores for each DSD are all possible influencing variables. However, if the goal is to close the creativity gap between higher education and the workforce, the authors suggest that future work determine which disciplines experience the most substantial gains from the course. This will assist higher education programs with honing the skills training that they either integrate into curricula or require.

7. Conclusion

Considering the importance of creative ability to organizations who want to be competitive and relevant both today and tomorrow, creativity training is fundamental to college curriculum. This article presents findings that suggest that Creative Problem Solving significantly increases the ability to come up with more ideas, and different ideas. It may take time for creativity training to gain approval as a required course in college. However, our hope is that instructors from all disciplines find inspiration from this article to design opportunities for students to exercise and develop their creative abilities. As a final and related note, if colleges are to take responsibility in generating a more creative workforce, they must also acknowledge the role of faculty. Training that increases the creative abilities of instructors will empower them with the skills, strategies, and knowledge they need to foster the creative growth of their students.

8. References

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Assessment of Ideation Effectiveness in Design Thinking

The Impact of Morphological Analysis in the Process of Creative Problem Solving

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Creative problem solving (CPS) emerged as a critical soft skill for students, yet the evaluation and effectiveness of the CPS methods is not fully understood. This study examined the ideation effectiveness of junior design students. Students are asked to ideate for a complex challenge, a 1000-floor elevator in two phases, with a morphological analysis (MA) method introduced to them as an intervention after the first phase. This study evaluated the effectiveness of the MA method in the students' ideation process and their creative thinking by using four measures of novelty, quality, quantity, and variety using the quantitative and qualitative methods. The result of this study supports the positive impact of MA method in CPS process. Similar challenges to the 1000-floor challenge are recommended for the early sessions of design thinking courses to inform educators about students' creativity performance. Further, the quantitative assessment method of this study may be applied to assess the other CPS methods in design thinking courses.

Keywords: Creative Problem Solving, Morphological Thinking, Ideation Effectiveness Assessment, Design Thinking

Introduction

The twenty-first century's academic environments have to support and prepare students to read critically, think and reason logically, and solve complex problems (Rotherham & Willingham, 2009). Education find itself in a stage of transformation toward integrative thinking in order to facilitate students' learning skills. Design thinking (DT) has been extensively used as a process that can facilitate creative problem solving (e.g. Pressman, 2018; Pusca & Northwood, 2018; Razzouk & Shute, 2012; Wible 2020). Design thinking is accepted as a formal creative problem-solving method with the intent to foster innovation (Dell'Era, Magistretti, Cautela, Verganti & Zurlo, 2020). However, the effectiveness of DT methods and skills gained in design thinking courses remains understudied (Aflatoony, Wakkary & Neustaedter, 2018).

This study explored morphological analysis (MA) as a mechanism to support creative problem-solving and introduced an analytical research tool to improve the efficiency and measure the effectiveness of MA method in the ideation stage of design thinking process. There are a growing number of studies which investigate the cognitive actions in the experiential learning process which can significantly contribute to the understanding of design thinking pedagogy (Beckman & Barry, 2007; Bamberger, Schön & Schön, 1983; Gero & Milovanovic, 2020). This study aims to contribute to students' creativity in a DT ideation training session. We used the morphological analysis method to examine creative thinking and study its effectiveness as a creative problem-solving skill among students. DT courses should encourage students to develop many different approaches to the same project (Resnick & Rosenbaum, 2013). The goal is for students to think divergently and find new paths for solving problems (Dym, Agogino, Eris, Frey & Leifer, 2006).

A Review of The Literature in The Context of Creative Problem Solving

Creativity has emerged as a critical core soft skill for students in the 21st century, where students face complex problems (Mishra & Mehta, 2017; Razzouk & Shute, 2012). Educators across different disciplines seek to enhance their pedagogy to empower students with critical soft skills such as creative problem solving (CPS)



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and system level thinking (Cobb, Zhao & Visnovska, 2008; Rotherham & Willingham, 2009; Warr & West, 2020). Accordingly, universities across the globe have begun to integrate design thinking courses into their curriculum. Countries such as Singapore, China, Korea, and India are committed to introducing and integrating design thinking into their educational systems (Beckman & Barry, 2007). Previous studies that reviewed design thinking in educational context indicated that when learners confront a complex problem, they struggle in the ideation phase of design thinking. Studies noted that a significant impediment that hinders the students' ability for ideation is their struggle to overcome design fixations in order to generate novel ideas (e.g. Jansson & Smith, 1991; Linsey et al., 2010). Design fixation is defined as barriers to a solution by employing familiar solutions and neglecting to search for better options (e.g. Linsey et al., 2010; Perttula & Sipilä, 2007). CPS is explored as an effective mechanism that can enable students to create original, effective and novel solutions (Oldham & Cummings, 1996; Shen & Lai, 2018; Zhou & George, 2001). Further studies described CPS as a potent process that helps learners to create a concept that do not yet exist (Henriksen, Richardson & Mehta, 2017).

However, after more than two decades of design thinking education and training in higher education, the exposure and the degree of effectiveness of CPS exercises in design thinking curriculum remains understudied. Studies mentioned this gap in the literature on the assessment of the effectiveness of CPS among design thinking learners (Micheli, Wilner, Bhatti, Mura & Beverland, 2019; Razzouk & Shute, 2012). Evaluation metrics are important because it helps design thinking educators to assess the impact of a variety of methods and exercises in students' creativity skill in DT courses. This could in turn enable educators to make more informed decisions in aligning the desired or intended skills for students with candid exercises and challenges. Certain studies took a qualitative approach to report the performance of K12 students on CPS and design thinking using pre- and post- survey analysis (Aflatoony et al., 2018).

Previous studies suggested that a candid method to lower design fixation and diversify the ideation process is morphological thinking. Morphological analysis (MA) consists of a systematic attempt to investigate a complex problem by way of considering its key components (Rickards, 1980). The power of MA lies in its careful examination and exhaustive exploration of alternatives to each of the structural parts of a problem or product (Foray & Grüber, 1990). Thus, MA can be conducive in the ideation stage of design thinking process. Studies further confirm that MA is an appropriate analytical tool to address design fixation during the ideation process (Vasconcelos, Whitney, Moultrie & Crilly, 2016). The creativity literature asserts that when students confront a complex problem, they tend to focus on certain aspects of an object or a task and leave other important aspects alone (Duncker, 1945; Luchins, 1942; Maier, 1931), a process that was longed identified as design fixation.

1000-Floor Elevator Challenge

To conduct this study, we introduced students to an open-ended and complex challenge. The subjects of the study were junior-level university students pursuing a terminal undergraduate degree in visual communication design. Students were challenged to ideate and design for a 1000-floor elevator challenge, a problem inspired by a famous Google interview question¹ for designer applicants in order to assess their level of creativity and problem-solving skills.

We chose this challenge for the study based on the problem specifications that best served the purposes of this research. Research suggests that by exposing students to an open-ended and complex problem will result in developing a creative mindset (Henriksen et al., 2017). Studies suggest creativity is identified as one of the "habits of mind" (Wible, 2020), and it should be developed in early stages of education so that students could develop their "self-identification" as "creative" (Henriksen et al., 2017). Educators, therefore, are eager to promote the creative habits of mind in the sequence of divergent-convergent thinking (Dym et al., 2006) and through creative problem navigating (Henriksen et al., 2017) for a complex problem scenario. To achieve this end, students are taken out of their comfort zones and presented with a challenging scenario of an elevator for a 1000-floor building in which they are "intentionally work through getting stuck" (Watson, 2015). Students competed to sketch for all possible temporary and tentative ideas and to iterate back and forth between problem and solution.

Certain aspects of this problem were in the students' comfort zones. The familiarity with the problem's topic, the elevator, helped students to get off the ground while boosting their confidence level, so they could begin

¹ <https://uxdesign.cc/a-human-centered-design-approach-to-the-1-000-floor-elevator-challenge-9a16c35c49d7>

engaging with the challenge. The one thousand levels served as unexpected and critical component of the challenge and added a number of considerations to the discussion, namely selection mechanism of the floor and the elevator's multi-purpose interface, managing time inside the elevator, and efficient navigation of the crowd. These unexpected parts of the challenge were a central of the problem that integrated an unknown, open-ended elements and critical thinking to the challenge.

The 1000-level elevator challenge consisted of two phases. Because the test was conducted in person and during the COVID-19 pandemic, students were asked to work individually for the entire project. During each phase, students had 20 minutes to ideate and sketch for as many concepts as possible. In order to document the ideation and sketching consistently, we provided students with formatted 11x17" sketching sheet during each phase. Each sheet had a header for phase and stage of the ideation. Each sheet contained a large drawing section and a smaller textbox in case a description of the drawing should be accompanied. An example is provided in (Figure 1).

SKETCHING SHEET 1	PHASE 1	CONCEPT 1 : VISUALIZATION
	BRIEF CONCEPT DESCRIPTION Concept 1	Sketching Area (Concept 1)
	Text	

Figure 1. 11x17" sketching sheet- Phase 1

The first phase of the challenge initiated with a five-minute brief introduction of the problem for the students. To energize and motivate innovative thinking, we illustrated a few examples of breakthrough ideas in transportation system. These examples included Tesla Boring Company, Uber Flight Taxi and Tesla Hyperloop. We expected that introduction of these examples adversely impact the ideation process and we later evaluate the extend and scope of such potential design fixations.

During the first phase, students were not provided with specific aspects or any boundary condition limitations; rather the focus remained on the totality of designing the 1000-floor elevator. Students were encouraged to think through the state of the problem with as much detail as possible and sketch each idea separately. In the first round of ideation, each student was provided with 15 sketch sheets. Although we encouraged students to ideate and sketch as many concepts as possible, they were not required to use all the sketching sheets.

For the second phase of this study, we introduced morphological analysis (MA) as an intervention. MA helps the creativity process through principles of decomposition and forced association. Thus, in the second phase of the 1000-level elevator challenge, we break down the problem into three essential blocks and dimensions: a) elevator interface, b) elevator room design, and c) crowd navigation mechanism. As part of the intervention before the second phase, we introduced the 5Ws method (who, what, where, when, and why) to further motivate thought process. Students were encouraged to think about the following questions: who are the users? what is the problem they are trying to solve? where should each person stand in an elevator? when do users interact with the elevator(s)? We then asked students to ideate for each of these components. Students were given 10 new sketch sheets for each of the three components (a total of thirty sheets). All the sheets had the same format as the sketch sheets in the first phase except the title for the three categories.

Method

We took an empirical approach to evaluate effectiveness of students' ideation in the 1000-level elevator challenge. Two important questions that needed to be answered were what should be measured in the ideation process, and how it should be measured. We adopted the method that was introduced by Shah, Vargas-Hernandez & Smith (2003) in Design Studies Journal for a mechanical engineering project. This method was well received by the design community and was deployed by several studies to measure the effectiveness

of ideation (e.g. Charyton & Merrill, 2009; Nelson, Wilson, Rosen & Yen, 2009; Sarkar & Chakrabarti, 2011). While the majority of the studies that assessed ideation and creativity used surveys, observations, and qualitative approaches, there are advantages to using both quantitative and qualitative methods to conduct the measurement. Studies suggest this mixed method approach increases accuracy and consistency and provides more generalizable results (Abowitz & Toole, 2010). The quantitative approach suggests four objective metrics to be measured for ideation effectiveness: novelty, variety, quality and quantity (Shah et al., 2003). Novelty is a measure of how unusual or unexpected an idea is as compared to other ideas. Variety is a measure of the explored solution space during the idea generation process. The generation of similar ideas indicates low variety and hence, less probability of finding better ideas in other areas of the solution space. Quality, in this context, is a measure of the feasibility of an idea and how close it comes to meet the design specifications. Quantity is the total number of ideas generated.

This study employs a method of t-test to assess significance to determine if there is a significant difference between the means of two groups. The t-test is used as a hypothesis testing tool. Due to small sample size, the t-test is an appropriate measure because it does not require a minimum sample size as long as the p-value of the sample is significant. We used t-test statistic to analyse the data and to test the null hypothesis which states whether there is a significant difference between novelty, variety, quality, and quantity of the ideation effectiveness of the students.

For the purpose of 1000-level elevator challenge, we measured the novelty, variety, quality, and quantity of the ideation effectiveness of the test subjects during the first phase and compare them with the second phase of ideation. This comparison allows us to study the impact of the morphological analysis (MA) intervention in the creativity of the students' ideation. We further observed the design fixation throughout the ideation process. Previous studies suggest that MA method can have two important contributions in creative problem-solving in design thinking: first, MA can evaluate the proportion of the potential solution space explored by the designers; second, MA analysis could point out where the design fixation exist (Vasconcelos et al., 2016).

Analysis

Variable Definition and Coding

In accordance with the previous studies, we analysed the sketches and coded each ideation exploration to quantify and report a score for each of the four measures: quantity, variety, quality and novelty metrics. To measure quantity, we reported the total number of ideas generated by each student separately in each phase of the ideation process. Accordingly, we compared the result of the two phases to report the change quantity score of each student and also cumulative quantity score of class performance between phase 1 and phase 2. To measure variety, we studied sketches through a genealogical categorization i.e. how differentiated the ideas are from each other based on the physical and design principle (Shah et al., 2003). A higher score was an indication that the student explored a broader variety of concepts during the idea generation process. We reviewed each of the students' sketches by two evaluators independently, one time by the instructor and the second time by the graduate research assistant (RA) of the course and reported the average scores. Each of the two evaluators assessed how different two ideas were from each other considering the entire group of generated ideas. Similar concepts were not counted more than once.

To measure the quality, we defined the three different criteria based on previous literature: a) the quality of sketches, b) the extent of details in description of the concepts and c) the extent of comprehensiveness and systematic vision of the concept. We used four steps for grading of each criterion: a score of zero for weak performance, a score of 2 for average performance, a score of 4 as maximum grade possible in comparison with other students. We provided a score of negative 1 for lack of a component. This is in accordance with previous literature (Shah et al., 2003). The total score for quality is an average of the three criteria. To measure the quality, we did not expect students to design a functional elevator. Instead, we were interested in evaluating their systematic view and how far they could explore and think about the different aspects of the 1000-level elevator challenge. Figure 2 shows an example of students' ideation with high quality scores. To minimize potential bias, we conducted two independent evaluations of the quality, one by the instructor and one by the graduate research assistant. We evaluated quality scores for each student and for the whole class in phase one and phase two.

To measure the novelty, we first reviewed all students' sketches and consequently coded the sketches based on crucial functionalities of elevator. A survey of students' sketches and descriptions during the first phase revealed eight key functionalities: elevator motion, the propulsion mechanism of the elevator, elevator cabin, off boarding, elevator duct, number of elevators, location of elevators inside or outside of the building, and

scheduling. Students conceptualized the motions of the elevator as either linear, spiral, zigzag, circular, distortive circular or circular loop. Few of the sketches conceptualized the motion as spider climbing or a gigantic crane that moves the elevator with a freedom of direction. The propulsion mechanism included the common cable and rails mechanism but also included unusual propulsions, namely a gondola lift, Ferris wheel interlocked gears, trampoline, rocket, flying wings, helicopter rotor blades, water pump, side speed wheel, escalator, air pressure pump, and magnetic levitation. The elevator cabins were described as individual sized pod / capsules or the common cabin room.

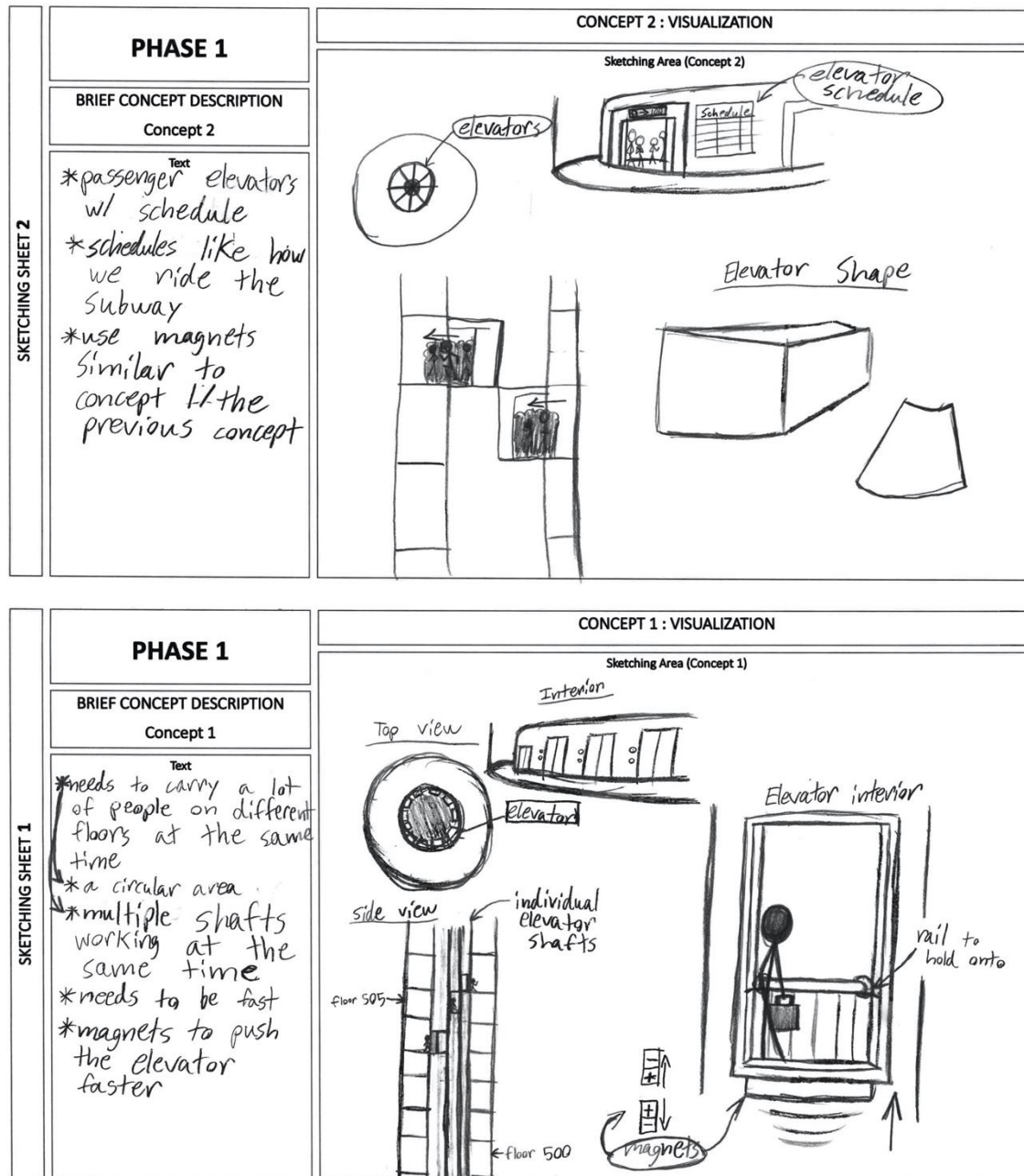


Figure 2. An example of a student's ideation with high quality score in phase 1 of ideation.

The off-boarding mechanisms in the sketches were explored as either a regular elevator door, multiple side doors in a single cabin, or parking stations for single pods. The elevator tunnel was ideated as common single elevator in a tunnel or multiple elevators or pods in the same tunnel. A number of elevators were either single or multiple elevators based on the floor level, e.g., one elevator only serves 1-100, second elevator served 101-200, and so on. Some sketches explored the elevator's location as outside of the building versus inside. Students also explored different ideas for scheduling of elevators: common fixed schedule, i.e., elevator roams

like a shuttle with fixed schedule; first come first serve, i.e., a priority schedule; or personalized reservation schedule of roaming. Figure 3 indicates an example of students' sketches for a high novelty score.

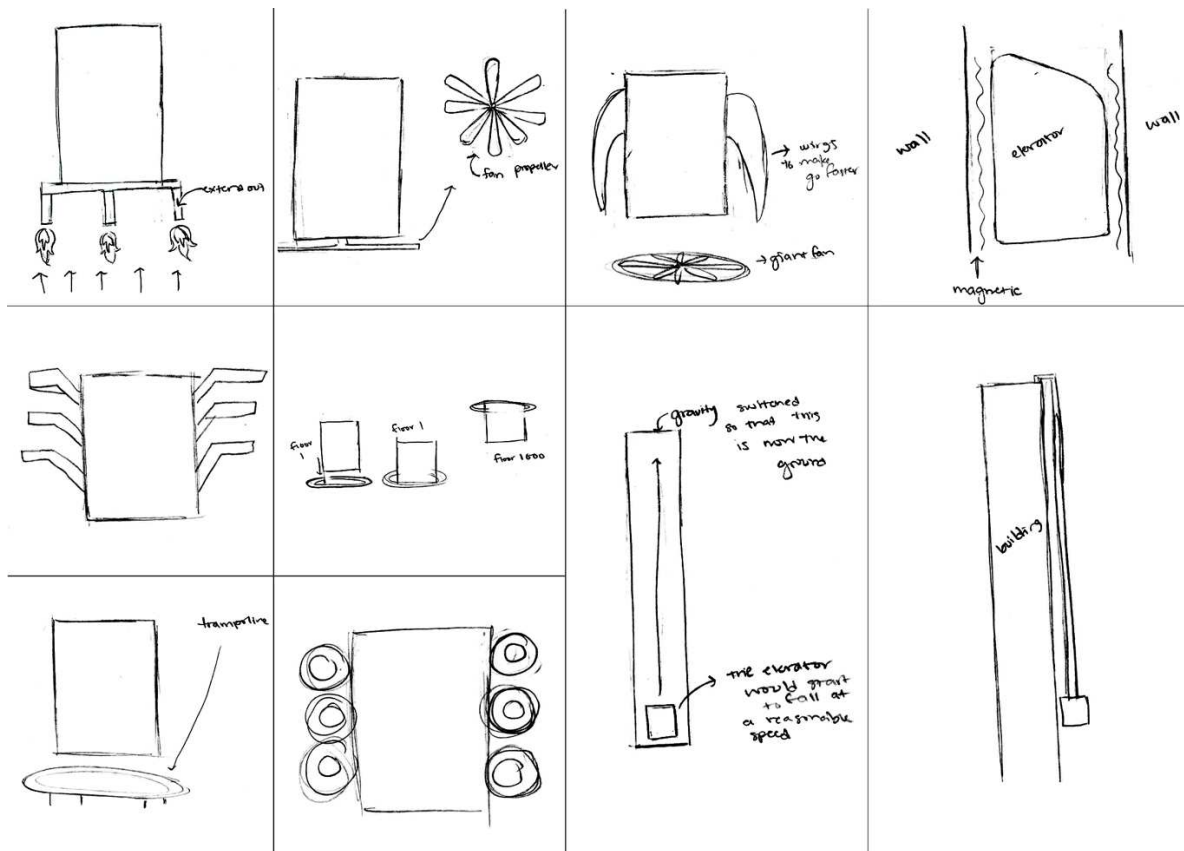


Figure 3. An example of a student's ideation with high variety and novelty score in phase 1 of ideation (Due to limited space, only the concept and not the entire sketching template is included).

In a similar process, we carefully reviewed student's effort for the expansion of their ideas in the second phase under each of three categories of a) elevator interface, b) elevator space (cabin), c) crowd navigation mechanism. A survey of students' sketches and descriptions revealed that students could expand on their ideas and produce overall a significantly higher number of sketches in the second phase of ideation. Hence, we created subcategories under each of the three major categories described above.

We recognized four major subcategories under elevator interface: interface panel, physical or remote-control system, navigation, and accommodation. Students' suggestions for elevator interface panel were diverse, suggesting traditional dial-pad panels, touch screen panel, Bluetooth connected speaker, mini smart portable device, touch screen digital stand panel outside the elevator, smart scanner, ticket scanner, voice recognition, and biometric scanner. Students explored different physical and remote-control mechanisms for the elevator interface such as common selection of the floor level, facial recognition, security operator, punch ticket, Uber style reservation, QR code, camera and fingerprint. Beside integration of a control system for the elevator interface, some students suggested complementary navigation mechanism for elevator interface ideation section. For instance, students recommended indoor GPS navigation, information panel about levels, smart elevator interface which recognizes the individuals and recommend a destination floor, and finally an application that directs elevator navigation to a user's cell phone.

Students thought the elevator interface could provide different services such as voice recognition or suggestion of estimated remaining time to an individual's destination. Students also suggested ancillary services namely charging outlets, online weather forecasts, including entertainment such as music or a TV channel. Figure 4 demonstrates the sample sketches of the students for elevator interface in the phase 2.

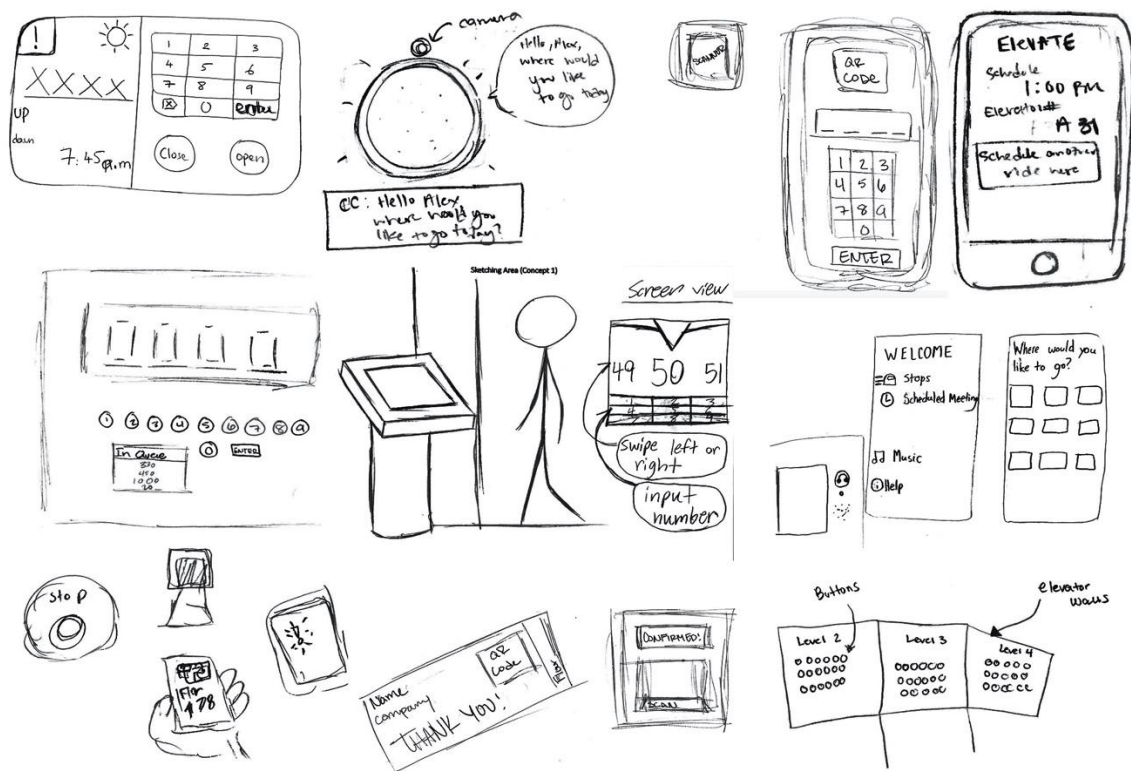


Figure 4. Sample sketches of the students for elevator interface, Phase 2

We summarized all the students' sketches and descriptions under crowd navigation in three major subcategories: space management, information system and control system. Students created a significant connection between the crowd navigation to space management both inside and outside of the elevator. Besides the regular elevator cabin, students ideated for a possible large common room, sectional or partition within the elevator cabin for better crowd navigation. Some sketches added seats on the cabin. Figure 5 is a sample of students' ideation for the elevator space.

For the outside space management, students recommended increasing the number of elevators, using a large number of transportation pods inside or outside the building, tracking the number of people in line for the elevator, and using VIP express capsules. Students advocated for information services that support crowd navigation. For example, signs on the floor, an information help desk, personalized elevator information through fingerprint, using light and weight sensors on the floor or a combination of smart screen and app to inform the riders were suggested by students.

Students specified that for a 1000-level building, the elevator space can have different shapes, interior designs and capacities and offered ideas to adapt the space for different users. For instance, the shape of the elevator cabin was drawn as normal cubic cabin, similar to a pod or capsule, bullet train, sectional cabin, and a giant common room. For interior design, students sketched normal seats, interactive bubble shape seats, sofa and calm space, revolving door sectional mechanism, transparent glass walls, smart space, small desk and pop-up office space within the elevators. Students also thought about capacity with a private space or a small space for a few people, sectional space with different capacity and shared large elevator cabin space. A few of the sketches suggested adapting the elevator space for different purposes, businesses, disabled users and etc. Figure 6 is a sample of students' ideation for crowd navigation in phase 2.

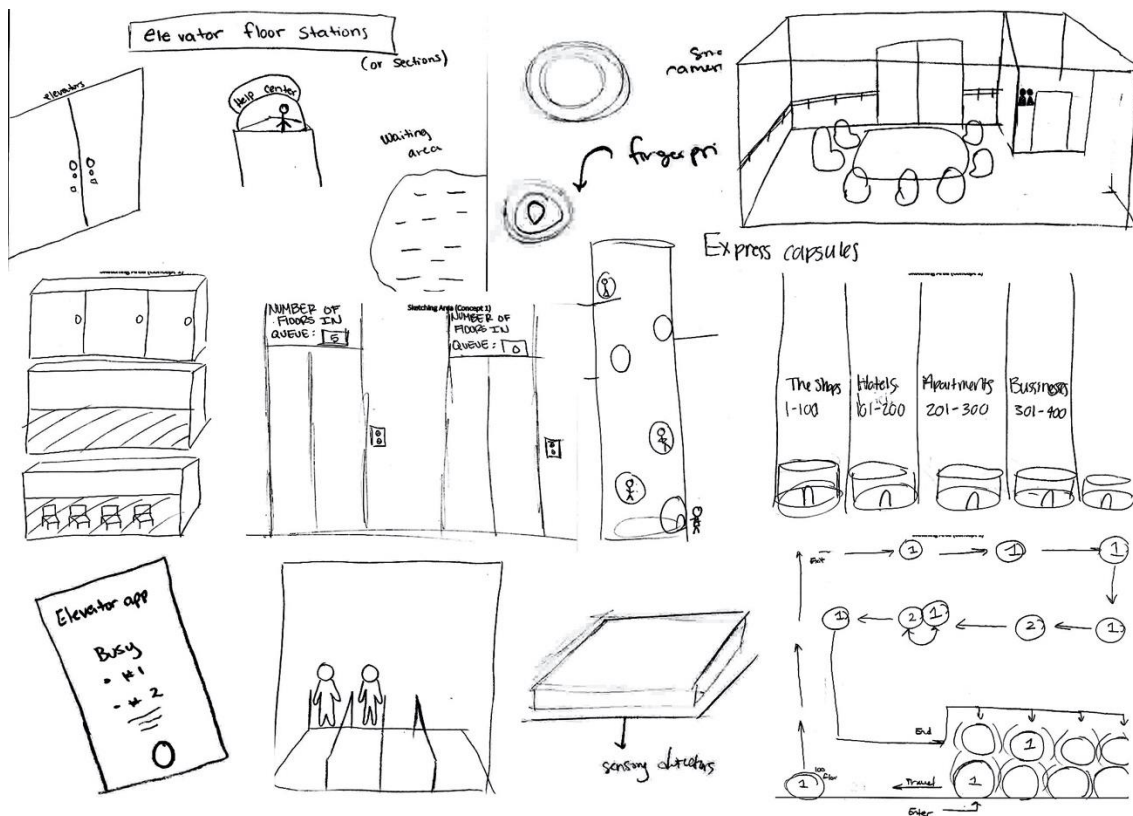


Figure 5. Sample of students' sketches for crowd navigation, phase 2

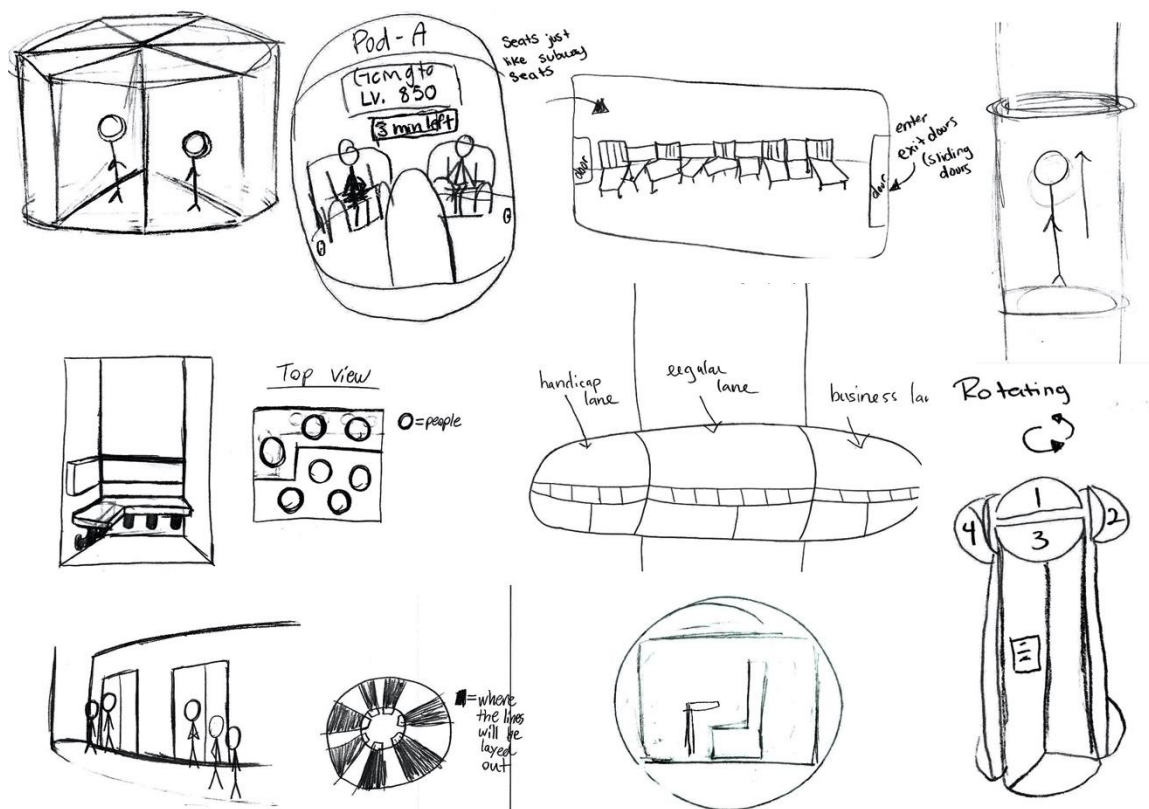


Figure 6. Sample students' sketches for elevator space, phase 2

Following previous studies (Shah et al., 2003), we calculated the novelty score for each student based on the formula below where n represents the number of attributes and m represents the number of subcategories

within each attribute. As an example, in the first phase, we have eight attributes as explained above, therefore $n = 8$. For motion attribute, we have seven subcategories as explained above, therefore $m = 7$. The indicator θ represent the number of sketches submitted by a student that ideated on a specific subcategory. For instance, in the first phase, a student submitted three sketches that used magnetic levitation under propulsion attribute, therefore $\theta = 3$. f represents the weight of each attribute based on the importance or significance of the attribute. Finally, S represent the score for each subcategory based on how common vs unexpected was the proposed idea in the students' sketches. This score is calculated based on the total number of sketches presented (noted by T), and the total number of sketches that referenced the subcategory (denoted by C) For instance, during the first phase, students submitted 64 sketches, thereby $T = 64$, from which 20 of the sketches referenced magnetic levitation as a propulsion mechanism, therefore $C = 20$. Accordingly, $S = [(64 - 20) / 64] \times 10 = 6.88$.

$$\text{Novelty Score} = \sum_{j=1}^m f_j \sum_{k=1}^n S_{jk} \times \theta_{jk}$$

$$S_{jk} = \frac{T_{jk} - C_{jk}}{T_{jk}} \times 10$$

Outcome

The result on variation of quality sketches in the first versus second phase is reviewed in Table 1. Overall, outcomes of the study suggest the quality of sketches did not significantly change from the first phase to the second phase of ideation (t-Stat = 0.16, p-value = 0.87). Thus, students kept a similar quality of sketching performance during both phases of the challenge.

Table 1. Results for quality of participants' sketches in the first phase of ideation, the three categories of elevator space, elevator interface, and crowd navigation in the second phase, as well as the overall quality in the second phase of ideation.

Quality Score	Phase 1	Phase 2: Elevator Space	Phase 2: Elevator Interface	Phase 2: Crowd Navigation	Phase 2: Overall
Student #1	2.27 (1.69)	-1.75 (0.35)	2.90 (2.29)	-2.25 (0.35)	-0.37 (2.99)
Student #2	4.28 (2.02)	3.00 (0.82)	8.00 (1.73)	4.50 (2.12)	5.17 (2.65)
Student #3	7.05 (2.11)	3.70 (1.79)	3.65 (0.94)	1.79 (1.22)	3.05 (1.49)
Student #4	7.29 (1.80)	10.50 (2.12)	11.00 (1.41)	11.50 (0.71)	11.00 (1.26)
Student #5	6.67 (5.13)	9.00 (1.41)	8.75 (1.50)	7.50 (3.54)	8.42 (1.85)
Student #6	6.50 (3.94)	3.00 (2.65)	5.67 (1.53)	6.17 (5.35)	4.94 (3.41)
Student #7	12.00 (0.00)	12.00 (0.00)	10.00 (2.00)	12.00 (0.00)	11.33 (1.67)
Student #8	1.18 (1.72)	8.00 (4.69)	4.33 (2.02)	12.00 (0.00)	8.11 (4.22)
Student #9	9.25 (3.77)	2.00 (2.65)	2.17 (3.01)	2.80 (3.35)	2.32 (2.80)
All Students	6.28 (3.66)	5.49 (4.37)	6.27 (3.27)	6.22 (4.67)	6.00 (3.98)

Table 2 exhibits the quantity of participants' sketches during both phases. Given the students had the exact same time of 20 minutes during the first phase as well as the entire three subcategories in the second phase, we examined whether the morphological analysis intervention had any impact on the quantity of ideas among participants. The overall quantity score of the class increased from 64 sketches in the first phase to 93 sketches in the second, an increase of 45.3%. However, this increase is not significant within a 95% confidence interval.

The results are only significant within 85% confidence interval (t-Stat = -1.53, p-value = 0.15).

Table 2. Results for quantity of participants' sketches in the first phase of ideation, the three categories of elevator space, elevator interface, and crowd navigation in the second phase, as well as the overall quantity in the second phase of ideation.

Quantity Score	Phase 1	Phase 2: Elevator Space	Phase 2: Elevator Interface	Phase 2: Crowd Navigation	Phase 2: Overall	% Change from Phase 1 to Phase 2
Student #1	13	2	10	2	14	7.7%
Student #2	9	4	3	2	9	0.0%
Student #3	10	5	10	7	22	120.0%
Student #4	7	2	2	2	6	-14.3%
Student #5	3	2	4	2	8	166.7%
Student #6	5	3	3	3	9	80.0%
Student #7	2	2	3	1	6	200.0%
Student #8	11	4	3	1	8	-27.3%
Student #9	4	3	3	5	11	175.0%
All Students	64	27	41	25	93	45.3%

We further measured the diversity of the participants' ideas and compare the diversity score between the first and second phases (Table 3). The outcome suggested the diversity score increased from 51 for the entire sample in the first phase to 81 in the second phase, an increase rate of 58.8%. However, this increase is also not significant within 95% confidence interval. The results are only significant within 87% confidence interval (t-Stat = -1.6, p-value = 0.13).

Table 3. Results for variety of participants' sketches in the first phase of ideation, the three categories of elevator space, elevator interface, and crowd navigation in the second phase, as well as the overall variety in the second phase of ideation.

Diversity Score	Phase 1	Phase 2: Elevator Space	Phase 2: Elevator Interface	Phase 2: Crowd Navigation	Phase 2: Overall	% Change from Phase 1 to Phase 2
Student #1	12	4	2	1	7	-41.7%
Student #2	5	3	3	2	8	60.0%
Student #3	10	10	5	7	22	120.0%
Student #4	5	2	2	2	6	20.0%
Student #5	2	4	2	2	8	300.0%
Student #6	5	3	2	3	8	60.0%
Student #7	2	2	3	0	5	150.0%
Student #8	8	2	4	1	7	-12.5%
Student #9	2	3	3	4	10	400.0%
All Students	51	33	26	22	81	58.8%

Finally, the fourth and the most significant result of this study is the measure of the novelty score in the ideation effectiveness analysis. The novelty scores for participants during the first phase is displayed in Table 4. The eight columns contain the novelty score of each attribute explained in the previous section for each of the participant. The numbers in parentheses are the standard deviation of the scores. The second row of the table demonstrate the weight of each attribute. We used a non-uniform weight based on the significance of each of the attributes in the ideation process. The third row of Table 4 represents the number of subcategories under each attribute as explained in the variable definition and coding section.

Table 4. Results of novelty scores for each of the attributes for participants during the first phase of ideation

Novelty Attributes	Elevator Motion	Propulsion Mechanism	Elevator Cabin	Off-Boarding	Elevator Duct	Number of elevators	Location of elevator	Scheduling	Novelty Score
Score Weight	30%	30%	10%	10%	5%	5%	5%	5%	100%
No Subcategories	7	14	3	3	2	2	2	3	
Student #1	6.86 (3.33)	6.97 (3.45)	4.23 (2.31)	2.88 (2.29)	2.64 (2.46)	1.59 (0.00)	2.38 (1.65)	0.94 (0.00)	5.24 (2.17)
Student #2	4.11 (2.73)	5.85 (3.62)	4.74 (2.50)	3.32 (2.64)	1.59 (0.00)	1.59 (0.00)	5.34 (3.08)	0.94 (0.00)	4.27 (2.19)
Student #3	3.38 (2.16)	7.70 (3.64)	2.97 (0.00)	1.90 (0.00)	2.27 (2.05)	2.27 (2.05)	3.14 (2.48)	0.94 (0.00)	4.24 (1.86)
Student #4	4.53 (2.96)	6.44 (2.42)	7.86 (2.00)	6.44 (2.87)	6.46 (3.08)	2.56 (2.39)	1.90 (0.00)	3.35 (3.81)	5.43 (2.51)
Student #5	2.66 (0.00)	2.96 (2.77)	2.97 (0.00)	4.55 (3.74)	1.59 (0.00)	6.14 (3.22)	3.97 (2.92)	3.75 (3.98)	3.21 (2.50)
Student #6	6.66 (3.27)	4.53 (2.88)	7.31 (2.18)	4.44 (3.11)	4.32 (3.34)	5.68 (3.34)	3.14 (2.48)	4.44 (4.29)	5.41 (2.99)
Student #7	2.66 (0.00)	6.88 (0.00)	2.97 (0.00)	1.90 (0.00)	1.59 (0.00)	8.41 (0.00)	1.90 (0.00)	5.16 (4.22)	4.20 (1.41)
Student #8	3.25 (1.89)	5.21 (3.97)	4.46 (2.44)	1.90 (0.00)	1.59 (0.00)	2.83 (2.63)	3.03 (2.39)	0.94 (0.00)	3.60 (2.05)
Student #9	2.66 (0.00)	1.00 (0.00)	2.97 (0.00)	1.90 (0.00)	1.59 (0.00)	1.59 (0.00)	1.90 (0.00)	0.94 (0.00)	1.89 (1.31)
All Students	4.45 (2.98)	5.81 (3.66)	4.60 (2.52)	3.14 (2.55)	2.67 (2.49)	2.67 (2.49)	3.08 (2.43)	1.74 (2.49)	4.36 (2.65)

The results of the novelty score for the three categories in the second phase is presented in Table 5 (crowd navigation), Table 6 (elevator interface), and Table 7 (elevator space). The result reveals the morphological analysis intervention made a positive impact from the first to the second phase in the process of creative problem solving. We recorded an increase in the novelty score from 4.36 in the first phase to 7.3 in the second phase, an increase of 67.4%. This increase is significant within a 99.99% confidence interval (t-Stat = 6.88, p-value = 0.00).

Table 5. Results of novelty scores for each of the attributes for participants during the second phase of ideation for crowd navigation categorization

Novelty Attributes	Space Management	Information System	Control System	Novelty Score
Score Weight	33.3%	33.3%	33.3%	100%
No Attributes	10	8	9	
Student #1	8.80 (0.00)	4.40 (0.00)	5.20 (0.00)	6.13 (0.00)
Student #2	8.00 (0.00)	9.00 (0.20)	9.00 (0.60)	8.67 (0.37)
Student #3	8.34 (0.40)	7.89 (2.22)	8.57 (1.46)	8.27 (1.55)
Student #4	8.60 (0.60)	7.00 (2.60)	9.40 (0.20)	8.33 (1.54)
Student #5	8.80 (0.80)	9.20 (0.40)	8.80 (0.40)	8.93 (0.57)
Student #6	8.93 (0.68)	4.40 (0.00)	6.53 (1.89)	6.62 (1.16)
Student #7	8.00 (0.00)	9.20 (0.00)	5.20 (0.00)	7.47 (0.00)
Student #8	9.20 (0.00)	4.40 (0.00)	5.20 (0.00)	6.27 (0.00)
Student #9	9.20 (0.25)	4.40 (0.00)	5.20 (0.00)	6.27 (0.15)
All Students	8.67 (0.60)	6.53 (2.41)	7.23 (1.99)	7.48 (1.84)

Table 6. Results of novelty scores for each of the attributes for participants during the second phase of ideation for elevator interface categorization

Novelty Attributes	Interface Panel	Physical / Remote Control	Navigation	Accommodation	Novelty Score
Score Weight	35%	35%	25%	5%	100%
No Attributes	10	11	6	7	
Student #1	7.20 (0.93)	7.27 (1.46)	7.12 (1.43)	4.20 (2.54)	7.05 (1.70)
Student #2	9.02 (0.40)	9.27 (0.40)	8.78 (0.69)	2.93 (0.00)	8.74 (0.45)
Student #3	9.17 (0.31)	8.88 (0.98)	7.44 (1.72)	4.90 (3.02)	8.42 (1.81)
Student #4	9.39 (0.37)	9.39 (0.12)	8.90 (0.61)	6.34 (3.41)	9.12 (1.75)
Student #5	8.23 (0.97)	7.56 (1.47)	6.83 (1.46)	6.16 (3.24)	7.54 (1.98)
Student #6	8.29 (1.24)	8.05 (1.39)	6.34 (1.38)	2.93 (0.00)	7.45 (1.16)
Student #7	7.24 (0.92)	6.10 (0.00)	6.34 (1.38)	4.96 (2.87)	6.50 (1.66)

Student #8	7.56 (1.38)	6.10 (0.00)	5.37 (0.00)	7.15 (3.00)	6.48 (1.65)
Student #9	8.29 (1.24)	9.27 (0.40)	6.50 (1.61)	5.12 (3.10)	8.03 (1.87)
All Students	8.21 (1.21)	7.97 (1.53)	7.09 (1.64)	4.82 (2.94)	7.68 (1.95)

Table 7. Results of novelty scores for each of the attributes for participants during the second phase of ideation for elevator space categorization

Novelty Attributes	Elevator Shapes	Interior Designs	Capacity	Space Adaptation	Novelty Score
Score Weight	30%	50%	10%	10%	100%
No Attributes	6	9	3	2	
Student #1	6.67 (0.37)	5.93 (0.00)	7.04 (0.00)	1.11 (0.00)	5.78 (0.19)
Student #2	7.22 (0.81)	7.69 (1.76)	5.19 (0.00)	1.11 (0.00)	6.64 (0.97)
Student #3	7.85 (1.00)	8.96 (0.68)	6.44 (1.06)	1.11 (0.00)	7.59 (0.81)
Student #4	7.96 (0.93)	8.52 (0.37)	7.41 (0.37)	1.11 (0.00)	7.50 (0.53)
Student #5	6.30 (0.00)	7.59 (1.67)	6.48 (1.30)	1.11 (0.00)	6.44 (1.06)
Student #6	7.90 (1.22)	6.67 (1.05)	5.19 (0.00)	3.70 (3.67)	6.59 (2.00)
Student #7	7.41 (1.11)	5.93 (0.00)	7.41 (0.37)	1.11 (0.00)	6.04 (0.59)
Student #8	7.13 (1.44)	8.89 (0.52)	6.48 (1.30)	5.00 (3.89)	7.73 (2.19)
Student #9	7.41 (1.09)	7.04 (1.57)	6.42 (0.87)	1.11 (0.00)	6.49 (1.05)
All Students	7.38 (1.14)	7.71 (1.55)	6.31 (1.12)	1.98 (2.44)	6.90 (1.65)

The values of t-statistics and p-values that were reported after each of the measures is summarized in Table 8. For instance, the null hypothesis for the t-Statistics and p-value is whether the scores in the first phase equals the scores in the second phase. If the value of t-Statistics falls between the t-Critical and the negative of t-Critical, the null hypothesis cannot be rejected. Accordingly, we cannot reject the null hypothesis for quality, quantity, and diversity; thus, they are not significant within 95% confidence. However, the table reveals that the null hypothesis is rejected for the novelty score, thus the results are strongly significant.

Table 8. Values of *t*-Statistics, and *p*-values for a comparison of students' scores in four measures of novelty, quality, quantity, and diversity

	Novelty (phase 1 vs phase 2)	Quality (phase 1 vs phase 2)	Quantity (phase 1 vs phase 2)	Diversity (phase 1 vs phase 2)
t-Stat	-6.88	0.16	-1.53	-1.60
P(T<=t) two-tail	0.00	0.87	0.15	0.13
t Critical two-tail	2.16	2.12	2.13	2.13

Concluding Discussion

This study evaluated the effectiveness of ideation in design thinking process using the study of an 1000-floor elevator challenge. In the ideation stage, design thinking promised to provoke students to think divergently and to find new paths for solving problems (Dym et al., 2006; Dunne & Martin, 2006; Resnick & Rosenbaum, 2013). The challenge has been conducted in two phases using morphological analysis methods as an intervention between the two phases. The result informed the study about the impact and effectiveness of the morphological analysis method in the creative problem-solving process. We compared the first and second phases by measuring the quantity, variety, quality and novelty metrics, and we found evidence of a considerable enhancement in novelty, and a relative increase in quantity and diversity score in the process. The most significant impact was the improvement of novelty between the two phases. Figure 7 shows a representation of the results of such improvement as explored in Tables 4-7 in the Results section.

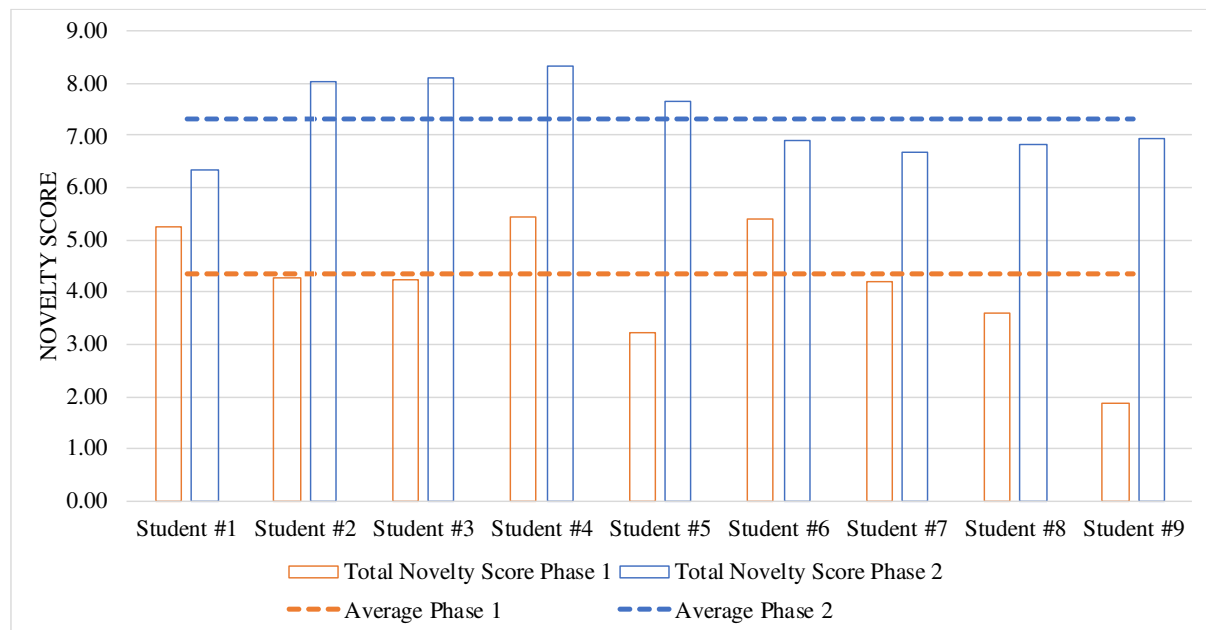


Figure 7. Comparison of novelty score of participants' sketches during first versus the second phase of ideation

The 1000-level building added an unexpected and complex component to the challenge which disrupted the students' routine thinking about an elevator, therefore, detaching students from their confidence zone in a way that sparked creativity and learning. Studies highlight the exposure to complex problems increases the likelihood of transfer of creative problem-solving skills to students (Sternberg & Lubart, 2014).

The evaluation process of the novelty score contributed to another finding in the study. Prior to the first phase of the challenge, we showed a few case examples to motivate creative and innovative thinking. The three examples were Tesla Boring Company, Uber Flight Taxi and Tesla Hyperloop which were the indirect examples of high technology and innovative concepts in a transportation system. Analysis of the coding of the sketches revealed a design fixation of the above examples in the students' sketch concepts. Students were inspired by Tesla Hyperloop and referenced the shape and mechanism of the Hyperloop in their concepts. Previous studies also confirmed the type of information available during idea generation will impact the creativity of the generated ideas (Montag-Smit & Maertz, 2017; Mumford et al., 1996). Studies suggest that design thinking

educators' choice of example in facilitating the ideation sessions would have a significant impact on the usefulness and novelty of ideation. The information directly relevant to problem solutions (factual) increases usefulness while indirectly relevant (range) for the specific problem increases the novelty (Mumford et al., 1996). While the study offered indirect information to students, we expected the novelty to increase in both phases. Nevertheless, we observed the novelty increase from the first phase to the second phase after the intervention. Future studies may assess the moderating effect of indirect information and morphological analysis. Integration of the morphological analysis method with coding analysis is useful to reflect the effects of the examples in the students' ideation and focusing on information that is "in the box" for enhancing the quality and usefulness of ideas or "outside the box." to enhance the novelty (Montag-Smit & Maertz, 2017). In addition, the result can also contribute to recognition of possible design fixations in the ideation process, specifically if any of the initial examples have caused a significant bias in the final concepts results. Therefore, educators can take advantage of the mixed method of MA and coding analysis process to strategically review the impact of the factual and range examples in the students' ideation process.

The final result of the coding can further contribute to formation of teams based on the creativity performance of participants. Previous studies emphasized the challenges and difficulties in the team designing in projects (e.g. Aapaoja et al., 2013; Valkenburg & Dorst, 1998). The teams' performances are linked to synchronizing the thoughts and activities of the team members (Valkenburg & Dorst, 1998). Also, students have different capabilities in creative problem-solving process (Beckman & Barry, 2007). The results from this study suggests that students have different potential in ideation process. The individual creativity scores can vary and sometimes an individual with a significantly high performance in some of the four scores of quality, quantity, diversity and novelty, may not perform well in the rest, i.e. a nonconformity among the individuals' scores is common. Therefore, the individual scores can be consequential for educators when they want to decide on creating the teams for the projects. This is critical in the function of the teams because in a complex design project teams are best served when they have representation from different thinking styles. Each of the learning styles are necessary to successfully execute the innovation process (Beckman & Barry, 2007). Therefore, this study recommends that similar challenges to the 1000-level elevator challenge with a deep assessment in the early phases of a design thinking course can be very productive for educators because they provide detailed information about students' creativity performance leading to better matches for students' team projects.

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Study on the Implementation of the Innovative Enterprise Product Design Model for ID Students

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Industrial design education often prompts students to focus on creativity and user needs, and lacks knowledge and concepts in marketing and sales. Thus, this study proposed the “Innovative Enterprise Product Design Model” and planned a teaching course to teach the theoretical knowledge and application methods of this design model. Solving the problem where students’ designs are often out of touch with the industry. This study is divided into three stages. The first stage invites industrial design students to carry out product design using this design model. The second stage invites experts to evaluate the students’ design results. For the third stage, students are invited to fill in the feedback questionnaire. According to the study results, the students believed that they performed well and improved their innovation ability, product strategy formulation, and design maturity. They were also able to master the operation of the design model. The experts also believed that the design achievements were excellent in all aspects. And the results also proved the feasibility of this design model.

Keywords: development strategy; design education; design model; Industrial Design

1. Introduction

The cultivation of industrial design education is a profound subject, and compared with other fields such as science, humanities and business management, design studies are not as clearly defined. With the evolution of the times, the field of industrial design is no longer limited to the exploration of products, but has expanded to service design, experience design, sustainability design, and social design, which studies the interaction between products and the environment, systems, experiences and services (Yenilmez & Bagli,2020). In recent years, the field of industrial design has become increasingly focused on achieving the goal of a circular economy (van Dam et al.,2020), which highlights its complexity, thus the education on design needs to emphasize the incorporation of interdisciplinary knowledge into the curriculum.

When faced with different design issues, designers need to consider the present market conditions, user requirements, and explore the engineering technology of the product. More importantly, the design proposal must have a certain degree of “feasibility.” In order to elevate the competitiveness of innovative products in the market, it is necessary to focus on the relationship between marketing, industrial design, and engineering technology during the design and development stage (Veryzer, 2005), such as the estimated cost of sales the products, technical feasibility, and product market positioning. Micheli et al. (2012) believe that the development of an innovative product requires the cooperation of experts in different fields. In addition to the aesthetics, functions, and materials of the product, designers must also pay attention to the commercial aspect of the product, which means that in addition to considering the desired product appearance from the user’s perspective, a mature product also needs to take into account the enterprise’s philosophy, resources, sales strategies, and market positioning from the perspective of the enterprise, since a product will only achieve stable profits in the market by understanding the needs and positioning of both the consumer and enterprise. However, the development of industrial design education often prompts students to focus on creativity and user needs, and lacks knowledge and concepts in marketing and sales, as well as the



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understanding of the company's organizational structure and the business model of products, which results in an insufficient level of maturity in the design by the students. Owing to the aforementioned factors, the final design is often too impractical, and fails to meet industry design standards.

The purpose of design is to resolve problems. To this end, the process of innovative design requires integrating, coordinating, and articulating various design elements (Alonso-García et al., 2020) to further refine the design results in each aspect. Innovative thinking is also an essential ability in the design field. Creative thinking enables designers to pursue solutions to design problems, and design educators must consider guiding students in mastering this ability through means and learning activities (Balakrishnan, 2021). Through sophisticated course arrangements, academic content and pragmatic knowledge are transformed into a vivid thinking model that helps students implement thinking in a smoother manner, reflect on the definition of design, and achieve the goal of good design (Andreasen, 2011).

To make up for students' shortfalls in comprehensive design thinking and improve the feasibility of students' product design, this study proposed the "Innovative Enterprise Product Design Model" and planned a six-week teaching course to teach the theoretical knowledge and application methods of this design model. It is hoped that this will help design students to improve their innovative design ability and insight into consumer needs, and at the same time to solve the problem where students' designs are often out of touch with the industry.

2. Innovative Enterprise Product Design Model

Based on the author's years of teaching experience in the field of design, students in industrial design often emphasize the "design approach" or the "aesthetics of design" during the design process. Thus, they are accustomed to implementing designs according to user needs or focusing on the functions, shapes, and materials of the product; these students are often less concerned about enterprise limitations when developing innovative products. To encourage students to think comprehensively from the perspective of users and enterprises while also elevating the feasibility of their design proposals, the Innovative Enterprise Product Design Model proposed in this study departs from the perspective of enterprise thinking. At the same time, this design model is proposed by the three authors of this study, and the operation process is divided into three major stages. Starting from the design thinking of "who are we?", the design methods and scope of thinking enable students to consider the enterprise and market orientations in design before proceeding to "design approach" and "excellent design" concepts to gradually complete the design task (see Figure 1). In addition, this design model is a conceptual design toolbox, allowing the user to use the appropriate method flexibly at each stage of design.

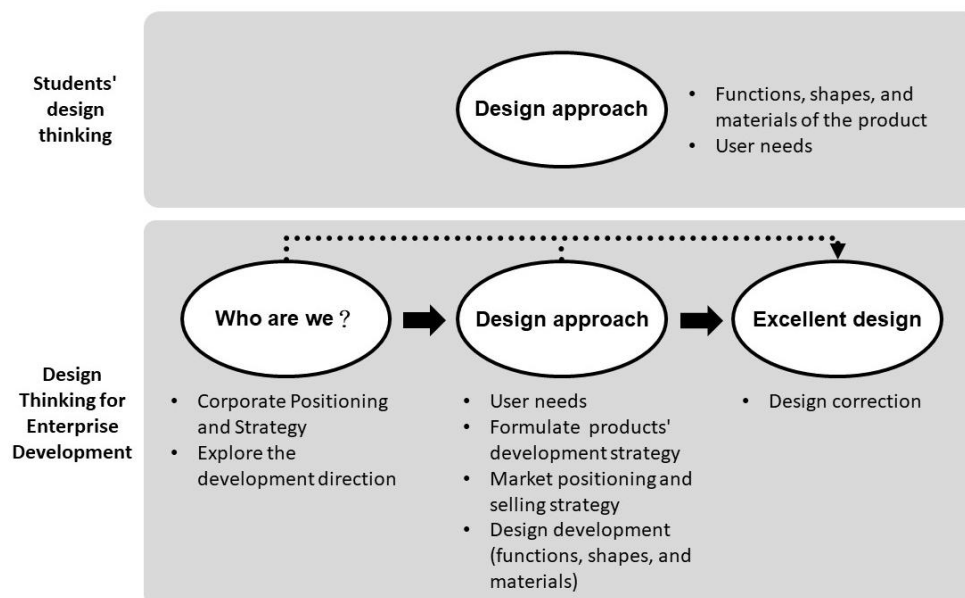


Figure 1. The difference between development thinking from an enterprise perspective and the design thinking from a student perspective

The "who are we" stage primarily explores the relationship between the enterprise, the market, and the users, and helps students to understand the existing market positioning of the enterprise and its resources, as well as

find a feasible product development direction. The “design approach” stage formulates the development strategy of innovative products from the research results obtained from the previous stage, and proposes the design that satisfies the enterprise’s development feasibility and the needs of users in regard to products and marketing. The final stage of “excellent design,” in addition to the development of a specific design result, the design result is checked to ensure it conforms to the design strategy through the use of design tools and methods, and then it is gradually modified to achieve maturity. The design model proposed in this study is shown in Figure 2. The following sections will introduce the tools and implementation processes used by each developing procedure.

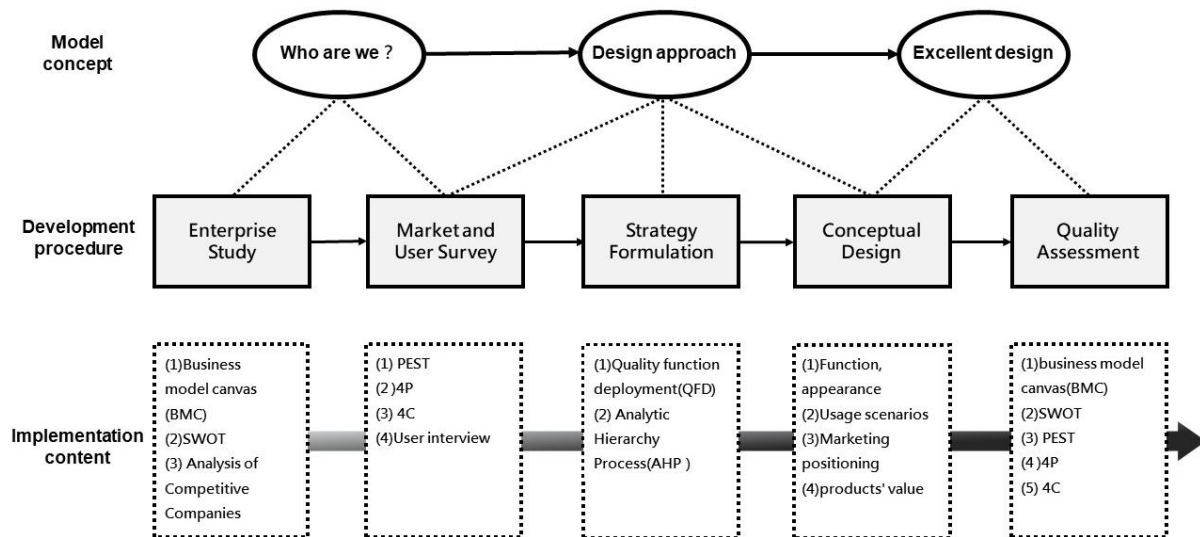


Figure 2. Development procedure and implementation content of the “Innovative Enterprise Product Design Model”

2.1 Enterprise Study

The beginning of the design stage involves learning about the types of products that can be developed to maximize both feasibility and enterprise profits. Therefore, the Enterprise Study stage is mainly focused on the nature of the enterprise. For enterprises, stable profits and continuous innovation are crucial factors. In addition to the efforts of the enterprise team, methods and tools are required for planning and for study. This study has researched academic literature and discovered numerous relevant methods and tools. Among them, the business model canvas (BMC) method has received considerable attention and is the most commonly used tool for the inspection of enterprise operation profiles. In this method, the value creation, value delivery, and value acquisition of a commercial system as well as the operation system are visualized and divided into the following nine segments: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnership, and cost structure. BMC helps organizations clearly analyze their current situation and conduct more efficient internal communication (Osterwalder & Pigneur, 2010; Koprivnjak & Oberman Peterka, 2020; Das et al., 2020; Hamwi et al., 2021). Strengths, weaknesses, opportunities, and threats (SWOT) analysis is a common management decision-making method that has been applied in various industries and enterprises, such as in management analysis of the fishery industry (Haapasaari et al., 2021) and the automobile industry (Li et al., 2020). The method has a two-dimensional structure that is used to identify relevant internal and external factors; when successful, this method helps businesses avoid incorrect strategy decisions through analysis and establish feasible strategies (Rousseau & Rousseau, 2021), which makes it a suitable tool.

Hence, the specific procedure of this model uses the BMC tool to analyze the current business operation model and the value provided by the enterprise, and analyze the positioning of the enterprise in the designated field, as well as the product strengths, weaknesses and company strategies of its competitors regarding external factors of the company. The SWOT analysis method is also utilized at the same time to analyze the existing strengths, weaknesses, opportunities, and threats from a macro perspective.

2.2 Market and User Survey

The “Market and User Survey” stage probes into the existing products currently sold by the enterprise, and

discusses the positioning, strengths, weaknesses and actual consumer experience of these products in the market to facilitate the formulation of subsequent development strategies.

PEST analysis is a method used to analyze macro trends such as politics, economic, social, and technology. This method provides a thinking framework that facilitates understanding of phenomena such as business operations, industry, and market growth cycles, which is why this analysis method is adopted to explore the opportunities and limitations in the development of existing product categories. The 4P analysis is then used to analyze the current status of competing products regarding price, product, promotion and place that will identify the feasible innovation opportunities and design constraints for the future innovative products of the enterprise. Thereinafter, the 4C analysis method is used to explore the products currently sold by the enterprise in terms of consumer's needs, cost, convenience, and communication from the consumer's perspective, and identify the design requirements and feasible opportunities for the future innovative products of the enterprise. After completing the above analytical steps, an interview outline based on the analysis results is formulated to thoroughly interview the needs of product users.

2.3 Strategy Formulation

The analysis results of the "Enterprise Study" and "Market and User Survey" indicate the product categories that are most feasible for the enterprise, thus the design team will jointly decide the product category to be developed in this stage, and set forth the design requirements and feasible engineering technologies for innovative products.

Quality Function Deployment (QFD) is a method used to ensure that customer needs can be converted into design objectives or engineering technology through quantitative calculation, where Pullman et al. (2002), Marsot (2005), Ginting & Ali (2016) and Mistarihi et Al. (2020) had also applied this method to product research, which illustrates the applicability of this method in the field of design. Therefore, this design model will use QFD for development and design, and calculate the order of importance for various engineering technologies that will be used as the optimal strategy for subsequent development and design. In addition, Analytic Hierarchy Process (AHP) is widely applied to solve decision-making and planning issues, and systematizes problems through hierarchical and quantitative methods to reduce the risk of failure (Saaty, 1977; Kutlu Gündoğdu et al., 2021); at the same time, this method is able to calculate the weight of various indicators. Hence, this method is adopted to calculate the weight of design requirements in the house of quality.

2.4 Conceptual Design

At this stage, the most feasible technologies among the top rankings according to the importance of the engineering technology as the design strategy for product development. Then, begin to design product functions, appearance, usage scenarios, or service experience, as well as formulate the market positioning and product value.

2.5 Quality Assessment

This stage uses methods, including BMC, SWOT, PEST, 4P and 4C, to determine whether the innovative product conforms to the design guidelines and market strategy before implementing adjustments and revisions.

3. Study Method

3.1 Study Flow

This study is divided into three stages. The first stage invites industrial design students to carry out product design using this design model. The second stage invites experts to evaluate the students' design results. For the third stage, students are invited to fill in the feedback questionnaire that will facilitate understanding of the influence of this design model on students' design ability.

3.2 Implementation Planning on the Operation of the Design Model

This study plans for a six-week teaching curriculum to teach students the theory and application of the design model, and gives students five weeks for data analysis, collection, and product design. The plan is shown in Figure 3. The design theme of this study is to "design a completely new line of products for the enterprise."

The choice of the enterprise is decided by the students. The participants of the design activities are 26 graduate and undergraduate students from the industrial design department of a certain university in Taiwan.

Week 1 – Week 2	Teach students the theory and operation of the business model canvas, SWOT, competitive enterprise analysis, PEST, 4P, and 4C.
Week 3 – Week 4	Teach students the theory and operation of the Quality function deployment (QFD) and the Analytic Hierarchy Process (AHP).
Week 5 – Week 6	Teach students the theory and operation of the Innovative Enterprise Product Design Model.
Week 7 – Week 11	Industrial design students to carry out product design using the Innovative Enterprise Product Design Model.

Figure 3. Curriculum of this study

3.3 Expert Evaluation Planning

This stage invites three experts in design education with an average of over five years of teaching experience to jointly formulate the evaluation criteria for the design results and the evaluation criteria weighting. The evaluation criteria are: E1-Products have market segmentation and positioning, E2-Products have usability, E3-Products meet the needs of target users, E4-Products attract consumer's desire to purchase, E5-Products conform to the spirit of enterprise values, and E6-Products are feasible for the enterprise.

Although the evaluation criteria for the student work has been finalized, it is difficult to provide a precise quantitative score for the strengths and weaknesses of the design work. This means that the behavior of scoring contains fuzzy attributes to a certain degree. Fuzzy comprehensive evaluation (FCE) is an evaluation method based on the Fuzzy theory, which can be used to evaluate all things with fuzzy attributes and transform qualitative evaluation into quantitative evaluation (Chueh, 2001; Zhang & Feng, 2018), and is also applied to the evaluation of product assembly design and operability (Ko, 2019), and that is why this study has chosen this method to evaluate the students' design work.

Next, 60 experts with a background in design or marketing management are invited to evaluate the students' design results according to the evaluation criteria. The evaluation method is conducted in the form of an online questionnaire. After the experts had read the design drawings and design descriptions, the design proposals are evaluated by the six evaluation criteria (E1-E6). The questionnaire rating scale was set as very bad, not good, fair, good, very good, with a total of 5 grades, expressed as $V = \{V1, V2, V3, V4, V5\} = \{\text{very bad, bad, fair, good, very good}\}$. Next, the evaluation results are established into a factor evaluation matrix. Finally, FCE is used to calculate and obtain a comprehensive evaluation result of each student's work.

3.4 Planning of Student Feedback Questionnaires

Three design education experts with an average of over 5 years of teaching experience jointly designed the questionnaire, which focused on innovation ability, the effectiveness of the design model, and operability. The questionnaire consisted of 9 questions (Table 1). All the student participants (26 students) completed the questionnaire after the study's design activity was completed.

Table 1. Design Model feedback questionnaire

Aspect	Question
A. Innovative design ability	A1. Does this design pattern elevate your innovative design ability for your design?
B. Design model effectiveness	B1. Does this design model help you in clarifying the current status and the design and development direction of the enterprise affiliated with your design? B2. Does this design model help you in realizing the needs of the users and the market for your design? B3. Does this design model help you in formulating the design and development strategy for your design? B4. Does this design model help you in increasing the design-conception ability for your design? B5. Does this design model help you in evaluating the quality of the design result for your design?
C. Operability	C1. How was the operability for the actual implementation of this design model?

4. Result and Discussion

4.1 Expert's evaluation on the design result

There are 64 experts in the evaluation questionnaire. Gender distribution: 34 male and 30 female experts. Age distribution: 21 experts are 21-30 years old, 36 experts are 31-40 years old, and 7 experts are over 41 years old. Professional field distribution: 36 experts are in the design field, and 28 are in marketing management. Education level distribution: 7 experts graduated from university/college, 48 experts hold a master's degree, and 9 experts hold a doctorate degree. Years of experience in design education: 11 experts have less than 5 years, 1 expert has 6-10 years, and 4 experts have over 10 years. Years of experience in marketing management education: 13 experts have less than 5 years, 2 experts have 6-10 years and 1 expert has over 10 years. Years of work experience in the related fields of product design, product planning, and marketing management: 36 experts have less than 5 years, 10 experts have 6-10 years, and 8 experts have over 10 years. In this study, the FCE method was used to analyze the students' designs. The calculation formula is:

$$\tilde{B} = \tilde{A} \circ \tilde{R} = (a_1, a_2, \dots, a_m) \circ \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{pmatrix} = (b_1, b_2, \dots, b_n), b_j = \bigvee_{i=1}^m (a_i \wedge r_{ij}), (j = 1, 2, \dots, n)$$

In this study, the vector $\tilde{A}=(0.286 \quad 0.143 \quad 0.095 \quad 0.238 \quad 0.048 \quad 0.190)$ is the weight of design requirements, which was jointly developed by three design education experts through a voting process, and a_t refers to the importance weight of the evaluation criteria ($1 \leq t \leq 6$). Factor evaluation matrix $\tilde{R}$ is a matrix created by summing and standardizing the results of the expert questionnaires. The value r_{mn} ($m = 1, 2, \dots, 6; n = 1, 2, \dots, 5$) in the matrix refers to the percentage of votes for the nth rating scale in the mth evaluation criterion.

In addition, the works from two groups of students have been selected from a total of eight groups for analysis and discussion due to the limitation of the length of this study. The results are shown as follows.

1. Designing a sports first aid kit for GIANT (Figure 4.)

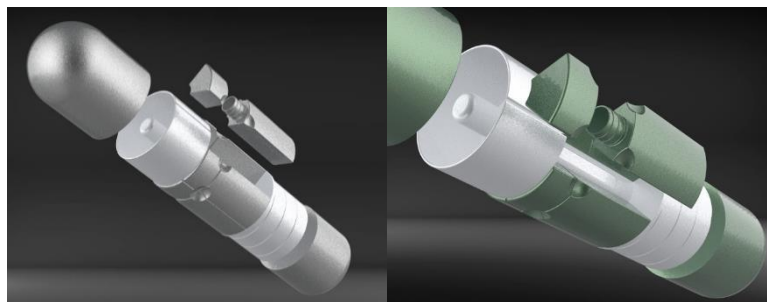


Figure 4. Gi-Aid sports first aid kit

- Design background and motivation: GIANT is a leading Taiwanese bicycle brand that emphasizes user-friendly designs that focus on “humanism,” and that a bicycle is not merely a transportation tool but a high-level pursuit in people’s daily lives. In the design pattern analysis, the student participants discovered that the number of people using bicycles for transport has been gradually increasing and with it the possibility of injury, which is when first aid kits are useful. Conventional first aid kits are neither convenient nor aesthetically pleasing; thus, the goal was to design a lightweight, trendy, health-protecting, and convenient first aid kit as well as to promote public awareness of health care and disaster prevention.
- Target group: The target group for the product is those with a relatively high disposable income who enjoy leisure and outdoor exercise.
- Product function and specification: The design highlights the redistribution and modularization of space utilization, resulting in a first aid kit tailored to the target group that subverts existing perceptions of first aid kits.
- Selling price and promotion: The product will be priced at roughly NT\$1000 and sold in specialty stores, retailers, and on the official website (accessories section). Authoritative individuals with medical backgrounds will be invited to endorse the product. Bloggers will be invited to review and recommend the product, and social media platforms will be used to enhance public impressions of the product. A monthly rental maintenance service will be offered for the kit after purchase.

Factor evaluation matrix is as follows:

$$\widetilde{R}_1 = \begin{bmatrix} 0 & 0.031 & 0.141 & 0.641 & 0.188 \\ 0 & 0.031 & 0.203 & 0.516 & 0.250 \\ 0 & 0.016 & 0.219 & 0.547 & 0.219 \\ 0.016 & 0.047 & 0.359 & 0.422 & 0.156 \\ 0 & 0.047 & 0.188 & 0.625 & 0.141 \\ 0 & 0.031 & 0.156 & 0.578 & 0.234 \end{bmatrix}$$

According to the statistical results, the experts suggested that, in terms of the design results in the aspect of “E1” evaluation criteria, the evaluation of 82.9% of the experts were good and very good. A total of 76.6%, 76.6%, 57.8%, 76.6%, and 81.2% of the experts evaluated the design results as “good” and “very good” for the dimensions of “E2,” “E3,” “E4,” “E5,” and “E6,” respectively. Next, this study calculated the FCE, and the calculation process is as follows:

$$\begin{aligned} \widetilde{B}_1 &= (0.286 \quad 0.143 \quad 0.095 \quad 0.238 \quad 0.048 \quad 0.190) \circ \begin{bmatrix} 0 & 0.031 & 0.141 & 0.641 & 0.188 \\ 0 & 0.031 & 0.203 & 0.516 & 0.250 \\ 0 & 0.016 & 0.219 & 0.547 & 0.219 \\ 0.016 & 0.047 & 0.359 & 0.422 & 0.156 \\ 0 & 0.047 & 0.188 & 0.625 & 0.141 \\ 0 & 0.031 & 0.156 & 0.578 & 0.234 \end{bmatrix} \\ &= (0.016 \quad 0.047 \quad 0.238 \quad 0.286 \quad 0.190) \end{aligned}$$

The FCE vector(0.016 0.047 0.238 0.286 0.190)as processed using normalization calculation, and the result was (0.021 0.060 0.306 0.368 0.245).According to the results, the design was evaluated as very good (24.5%), good (36.8%), fair (30.6%), bad (6%), and very bad (2.1%). This study interpreted the results from the perspective of the maximum degree of membership, the experts' evaluation of this design proposal reached a "good" level.

2. Designing a home robot vacuum for Tesla Inc. (Figure 5)

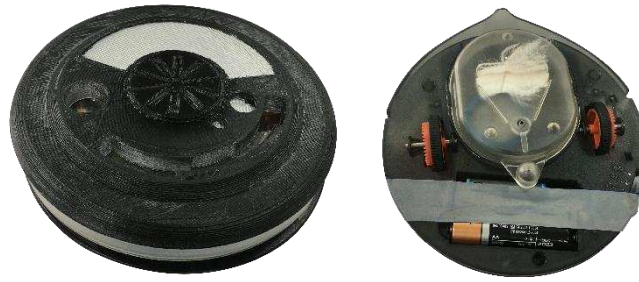


Figure 5. Intelligent Robot Vacuum

- Design background and motivation: Tesla is a leading American brand in electric vehicles with advanced battery technology and driving systems. The company focuses environmental protection and safety issues, while also ensuring that consumers enjoy high quality services. After analyzing and discussing through this design model, it is found that other manufacturers are currently pushing the electric vehicle market and are gradually catching up to Tesla's battery technology. At the same time, Tesla products are expensive with few maintenance sites and charging stations, which limits the consumer group to specific targets. In order to cultivate the image of Tesla and extricate the brand from the existing market that will generate additional targets for the brand, this proposal decided to design a unique robot vacuum that combines technology, innovation, environmental protection, and luxury, in the hope that consumers will enjoy a highly efficient and convenient clean environment, as well as experience a sense of luxury with the Tesla brand.
- Target group: Tesla drivers, high-income groups and busy consumers.
- Product function and specification: This product adopts Tesla batteries and is equipped with three wheels; two are driving wheels, and the third is a universal wheel. The product sensors, such as the drop-proof sensing device and a coding odometer, utilize infrared, visual, and ultrasonic transmission. The terminal processor uses printed circuit board assembly technology, and the cleaning structure includes a side brush, rolling brush, and garbage bin. Additional modules include a laser distance sensor module, a visual simultaneous localization and mapping sensor module, and a CleanBas self-cleaning base.
- Selling price and promotion: The predetermined price is about NTD 15,000, and will be sold in specialty stores and through online e-commerce. It will be advertised through TV advertising, social media platform launch, audio-visual platform advertising, industry distributions, endorsements, etc.

Factor evaluation matrix is as follows:

$$\widetilde{R}_2 = \begin{bmatrix} 0.047 & 0.234 & 0.250 & 0.422 & 0.047 \\ 0 & 0.125 & 0.297 & 0.453 & 0.125 \\ 0 & 0.125 & 0.422 & 0.406 & 0.047 \\ 0.047 & 0.219 & 0.266 & 0.391 & 0.078 \\ 0.031 & 0.125 & 0.438 & 0.359 & 0.047 \\ 0.031 & 0.156 & 0.297 & 0.391 & 0.125 \end{bmatrix}$$

According to the statistical results, the experts suggested that, in terms of the design results in the aspect of "E1" evaluation criteria, the evaluation of 46.9% of the experts were good and very good. A total of 57.8%, 45.3%, 46.9%, 40.6%, and 51.6% of the experts evaluated the design results as "good" and "very good" for the dimensions of "E2," "E3," "E4," "E5," and "E6," respectively. Next, this study calculated the FCE, and the calculation process is as follows:

$$\widetilde{B}_2 = (0.286 \quad 0.143 \quad 0.095 \quad 0.238 \quad 0.048 \quad 0.190) \circ \begin{bmatrix} 0.047 & 0.234 & 0.250 & 0.422 & 0.047 \\ 0 & 0.125 & 0.297 & 0.453 & 0.125 \\ 0 & 0.125 & 0.422 & 0.406 & 0.047 \\ 0.047 & 0.219 & 0.266 & 0.391 & 0.078 \\ 0.031 & 0.125 & 0.438 & 0.359 & 0.047 \\ 0.031 & 0.156 & 0.297 & 0.391 & 0.125 \end{bmatrix}$$

$$= (0.047 \quad 0.234 \quad 0.250 \quad 0.286 \quad 0.125)$$

The FCE vector(0.047 0.234 0.250 0.286 0.125)as processed using normalization calculation, and the result was (0.050 0.248 0.265 0.303 0.133).According to the results, the design was evaluated as very good (13.3%), good (30.3%), fair (26.5%), bad (24.8%), and very bad (5%). This study interpreted the results from the perspective of the maximum degree of membership, the experts' evaluation of this design proposal reached a "good" level.

4.2 Result of student questionnaire feedback

A total of 26 students have submitted the learning feedback questionnaire, including 10 males and 16 females. There were 21 sophomores (80.8%), 3 juniors (11.5%) and 2 masters (7.7%). The questionnaire is divided into innovative design ability, design model effectiveness, and operability. The statistical results are as follows.

1. Innovative design ability

In question A1, 23.1% of the students stated they achieved a very high degree of elevation in "innovative design ability," 38.5% stated high, 26.9% said medium, 7.7% stated slightly low, and 3.8% stated low.

2. Design Model effectiveness

In question B1, 30.8% of the students stated that this design model had provided a very high degree of help in "clarifying the current situation of the affiliated enterprise and the direction of enterprise's design and development." 61.5% stated high, 3.8% stated medium, and 3.8% stated slightly low. No one selected the option of low degree of help. In question B2, 34.6% of the students stated that this design model had provided a very high degree of help in "identifying users and market needs," 53.8% stated high, 7.7% stated medium, 3.8% stated slightly low. No one selected the option of low degree of help. In question B3, 38.5% of the students stated that this design model had provided a very high degree of help in "formulating their design and development strategy," 46.2% stated high, 15.4% stated medium. No one selected the options of slightly low and low degree of help. In question B4, 15.4% of the students stated that the design model had provided a very high degree of help in "enhancing design concept," 26.9% stated high, 42.3% stated medium, and 15.4% stated slightly low. No one selected the option of a low degree of help. In question B5, 26.9% of the students stated that the design model had provided a very high degree of help in "evaluating the quality of design results," 46.2% stated high, 19.2% stated medium, and 7.7% stated low. No one selected the option of low degree of help.

3. Operability

In question C1, 23.1% of the students stated that the operability of this design model was very high, 30.8% stated high, 34.6% stated medium, 11.5% stated slightly low. No one selected the option of low degree of help.

4. Discussion of statistical results

The statistical results show that in the aspect of improving innovation ability, more than half of the students (61.6%) believed that the use of this design model provided a significant level of positive help when developing innovative products and services for enterprises. This also represents that this design model formulates design strategies from the thought perspective of enterprises and users, and combines the design with the QFD method that facilitates outstanding results in innovative performance for students. Regarding the effectiveness of this design model, students believe that the design model provides the most significant help in clarifying the current situation of the affiliated enterprise and the design and development direction of the enterprise (92.3%). The second highest ranking is insight into the needs of the users and the market (88.4%). Third highest is formulation of the design and development strategy (84.7%), and the fourth is to evaluate the quality of design results (73.1%). The last is to increase the design concept (42.3%). From the results, it can be seen that this design model can help design students by equipping them with a more systematic approach in identifying the needs of the enterprise regarding product development during the early stages of design, and understand the positioning of the enterprise's existing products in the market, such that they can formulate

the development direction and strategies for subsequent innovative products. Simultaneously, it also proves that this design model can strengthen students' deficiencies in business analysis and marketing planning. However, this model is relatively weak in the aspect of increasing innovative ideas. Finally, regarding operability, 53.9% of the students stated that the design model has excellent operability, and most of the students were able to master the main techniques of the method from the six-week curriculum study. Although the learning process was rather arduous as it took a lot of time to collect and analyze data during the early stages of design implementation, this method can still help students in systematically speculating the direction of product development and design products that meet market needs.

5. Conclusion and Suggestions

An excellent designer is able to precisely define the appropriate scope of problems, properly prioritize the problems to be explored, and focus on the design solution (Cross, 2004). For students, precisely defining design issues and restricting the scope of the relevant issues is relatively difficult, for doing so requires prolonged cultivation and guidance from teachers. Furthermore, stipulating design strategies from the marketing perspective as well as producing designs that truly conform to market expectations, from product development to final sales, is essential. The development of innovative commodities increasingly emphasizes interdisciplinary teamwork (Micheli et al., 2012). Design schools must cultivate interdisciplinary communication and coordination abilities as well as arrange opportunities for students to cooperate with the industry or to implement design plans with students from different fields (Yenilmez & Bagli, 2020), which prepares students to thrive in the industry after graduation. However, in reality, design courses do not offer regular opportunities for cross-field cooperation outside joint courses with other departments or interdisciplinary classes for students from other departments. In addition, design professors typically have a background in the design field, which restricts their professional knowledge.

In conclusion, the aforementioned circumstances have created a predicament in current design education. However, according to the study results, the students believed that they performed well and improved their innovation ability, product strategy formulation, and design maturity. They were also able to master the operation of the design pattern. The experts also believed that the design achievements were excellent in all aspects. Specifically, the design pattern will both help enterprises in developing competitive innovative products and assist teachers in the design field in expanding the design vision of students to enterprise marketing; in this manner students are prepared to master the design standards of the industry after graduation. In addition, the study introduces a more comprehensive development orientation for design education. However, the focus of the study was improving student abilities in investigation, analysis, organization, and planning during the preliminary stage of design as well as the ability to draft design proposals that meet the needs of enterprises; thus, the design results were relatively insufficient in terms of product appearance and function details because of the limited time provided for the students to implement the design plan. The implementation duration of design plans may be extended in future studies, and a more profound exploration of functions, ergonomics, and aesthetic modeling may be conducted.

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A New Design Thinking Model Based on Bloom's Taxonomy

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A superior design thinking model can improve the quality of design education. In recent years, universities and design institutions already proposed many design thinking models around the world. Existing well-known design thinking models focus on cultivating students' creative thinking but ignore the product's inherent characteristics and users' demands. This paper proposes a step-by-step design thinking model based on Bloom's taxonomy, which is divided into lower-level and higher-level considerations. The lower-level consideration includes remembering, understanding, and applying, and the higher-level consideration includes analyzing, evaluating, and creating. The former integrates the function analysis method, form restriction method, and Evaluation Grid Method (EGM) to help students understand the target product and its users. The latter first evaluates any existing alternatives by using the AHP and then further redesigns the color and material of the highchair to provide an optimum solution. A highchair was used as the example product for classroom teaching. Classroom teaching results showed that the new design thinking model can help students understand target products and user demands, thereby improving the concept design's feasibility.

Keywords: Bloom's taxonomy; Design education; Design thinking model; AHP; EGM;

1 Introduction

In the 21st century, with technological advancements and changing user demands, the life cycle of products has gradually shortened. Many enterprise managers realized that a superior design could extend the product life cycle, thereby bringing greater benefits to the enterprise. An excellent design talent must include basic skills, good design thinking, creative thinking, critical thinking, and metacognition (Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., Rumble, M., & Rumble, M., 2012). The International Council of Societies of Industrial Design has also emphasized that cultivating students' thinking skills are more important than cultivating their technical skills (Cartier, 2011).

Design thinking is an activity that is implicit in the process of design. However, design thinking emerged only in the latter part of the twentieth century (Koh, J. H. L., Chai, C.S., Wong, B. and Hong, H. Y., 2015). According to Kimbell (2011), one of the earliest book-length treatments of the concept was in Peter Rowe's *Design Thinking*, published in 1987. Brown (2008) and Denning (2013) regard design thinking as an iterative process that can quickly develop and test multiple possible alternatives and finally obtain an optimal solution. Design thinking is a people-oriented approach to solving problems. However, the design thinking model has become an effective toolkit for the innovative design process, integrating various design tools and methods into the design process. Design thinking is a process that provides designers with abstract divergence and convergence of ideas. The design thinking model is a concrete toolkit. Modula design thinking has different stages and provides a structured framework (Sandars & Goh, 2020). After years of development, numerous design organizations and design colleges have proposed several classical design thinking models; these can clarify the design innovation process to provide a reference for designers or students. Tschimmel (2012) and Sandars and Goh (2020) analyzed several well-known design thinking models, including the 3 I model (Brown, 2008), the HCD model (<http://www.ideo.com/work/human-centered-design-toolkit>), the Double Diamond model (<http://www.designcouncil.org.uk>), the Design Thinking model of the Hasso-Plattner Institute (http://www.hpi.uni-potsdam.de/d_school/designthinking), and the Service Design model (Stickdorn &



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Schneider, 2010). In particular, the 3 I model involves three stages: inspiration, ideation, and implementation. The HCD model also involves three stages: hearing, creating, and delivering. The Double Diamond model involves four stages: discover, define, develop, and deliver. The Design Thinking model of the Hasso-Plattner Institute involves five stages: empathize, define, ideate, prototype, and test. Finally, the Service Design model involves four stages: exploration, creation, reflection, and implementation. The above-mentioned design thinking model mainly focuses on improving innovation in design activities, but it does not propose the logical relationship of each stage of the design methods according to the design thinking model to help students understand the characteristics of products and users' underlying demands.

Bloom (1956) proposed a taxonomy of educational objectives based on the perspective of cognition, which summarized educational goals into six stages: remembering, understanding, applying, analyzing, evaluating, and creating. Specifically, these six stages are a process from simple to complex, from abstract to concrete. Ben-Zvi and Carton (2008) applied Bloom's taxonomy to business courses. Lajis & Aziz (2018) proposed a model for evaluating computer students' learning efficiency based on Bloom's taxonomy. Sharunova et al. (2020) applied Bloom's taxonomy to engineering design courses and experimentally verified the effectiveness of Bloom's taxonomy. The abovementioned literature confirms that Bloom's taxonomy could improve teaching quality regarding various subjects. However, few scholars have combined Bloom's taxonomy with design education. Therefore, if a series of effective design methods could be integrated into it based on the six levels of Bloom's taxonomy, a useful step-by-step design thinking model could be proposed. This research is based on Bloom's Taxonomy's design thinking model. In the new design thinking model that understanding consumers' demand is a very important part. In the product innovation design stage, students understand consumers' demand through Evaluation Grid Method (EGM) interviews and sort out the three-layer hierarchical diagram to obtain design reference standards and program evaluation standards. This study's proposed design thinking model is divided into two levels: lower-level and higher-level considerations. The remainder of this paper is organized as follows. Section 2 describes the methods and theories involved in the new design thinking model, and Section 3 describes the implementation procedures for applying this design thinking model. Section 4 uses the product example of design the highchair in-class teaching as a case for describing how students carry out design activities based on these six stages. Finally, the last section provides this study's conclusions.

2 Theoretical background

This section describes the theoretical background related to the research of design education. It includes Bloom's Taxonomy, EGM, QTT I, function analysis method, form restriction method, and analytical hierarchy process. The aim is to clarify the new design thinking model and establish the basis for the case study by the theoretical background.

2.1 Bloom's Taxonomy

Bloom's taxonomy was first proposed by Bloom (1956), and Bloom's taxonomy includes three regions: cognition, emotion, and spirit (Anderson & Krathwohl, 2005). Among these, the cognition field is the most influential (Lahtinen & Ahoniemi, 2005). Subsequently, Bloom's students and other researchers revised Bloom's taxonomy. The revised taxonomy has been expanded to a two-dimensional matrix that combines successive knowledge with cognitive processes. The knowledge dimension represents from the concrete to the abstract, and the cognition dimension represents the assumption of complexity. This paper mainly uses the six stages of Bloom's taxonomy in the cognitive field along with design methods for generating a new design thinking model. The six stages are remembering, understanding, applying, analyzing, evaluating, and creating (Haring, P., Warmelink, H., Valente, M., & Roth, C., 2018). This research is based on Bloom's Taxonomy's use of EGM as the understanding part of the design thinking model. Therefore, the students obtain design reference criteria and evaluation criteria through the three-layer hierarchical diagram in the product innovation design stage. The design method used in this study follows Bloom's Taxonomy of design thinking models. The bold fonts as shown in Table 1 are the design methods applied in this research. The previous three stages were designated as the lower-level design thinking processes, which use the emanative design methods; The last three stages were designated as higher-level design thinking processes, which use the convergent methods (Narayanan & Adithan, 2015).

Table 4. The design thinking model follows Bloom's Taxonomy (this research collated).

Level	Design Method
Remembering	Literature Review, Data Collection , User diary;
Understanding	Evaluation Grid Method, Form Restriction Method, Function Analysis Method , Focus Group, Persona, Affinity Diagram, Scenario story, Brainstorming, Quantification Theory Type I, Competitive product analysis;
Applying	Prototype Design, Freehand Sketch, 3D modeling , Experience prototype, Service blueprint;
Analyzing	Comparison matrix , Factor Analysis, Regression Analysis;
Evaluating	Analytical Hierarchy Process , Grey Relational Analysis, Pugh, Fuzzy Comprehensive evaluation method;
Creating	Advance Design , Test Iteration;

The six stages are based on knowledge understanding, and they include continuous learning ranging from simple domains to complex domains. Each stage is followed by a knowledge ladder based on lower-level learning. After that, the middle-level is more complex than the previous stages, which is a prerequisite of different stages. Furthermore, the accumulated stage means that each higher-level stage contains the cognitive behavior of the next stage (Fig.1). Bloom's taxonomy is used for teaching in different faculties, and it can improve students' understanding and cultivation of learning skills; it can also enhance their critical thinking (Nentl & Zietlow, 2008). This study uses Bloom's taxonomy to integrate innovative course-teaching cases with progressive thinking processes and design thinking.

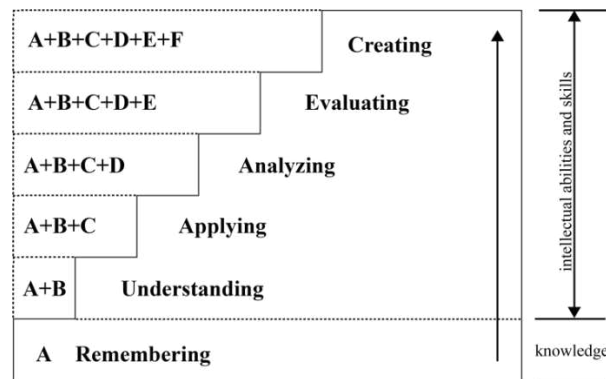


Figure 2. Phased and accumulative cognitive behavior of Bloom's taxonomy.

2.2 Miryoku Engineering and Evaluation Grid Method (EGM)

Miryoku engineering was proposed by a Japanese scholar Masato Ujigawa and his group, in 1991; it aims to focus on consumer preferences, and the main design concept involves creating attractive products (Ujigawa, 2000). Students can use in-depth interviews to identify attractive factors that attract users when they choose products and the products' charming elements, which can be comprehended in order to create popular products (Asano, 2001). Thus, Miryoku engineering is a method that applies consumers' image feelings toward product design and transforms them into design elements. Miryoku is a vague concept that cannot be measured with specific tools. Moreover, the evaluation grid method (EGM) is used for analyzing products' charming factors, which attract users; this allows designers to produce a three-layer hierarchical diagram. Students can use the acquired magnetic elements in the design to greatly enhance users' satisfaction. The EGM is one significant research method from the Miryoku philosophy of engineering; it is based on the psychologist's Repertory Grid Method of Kelly in 1986 (Kelly, 1955), and it was proposed by Japanese scholars Junichiro Sanui and Masao Inui. EGM can transform interviewees' abstract emotions into concrete emotions and capture users' emotions regarding products through in-depth interviews. First, participants were invited to compare and evaluate the merits of selected product sample photos during interviews, which aimed to obtain original evaluation items based on interviewees' perspectives and senses. Second, through repeated actions, EGM can classify the three-layer repertory of abstract reasons (upper layer) and original evaluation items (middle layer), which connect consumers' emotional attitudes and product concrete conditions (lower-layer) (see Fig.2) (Imai & Kawamura, 2009). Finally, Students organized interview data and structured a three-layer hierarchical diagram, which carefully analyzed attractive product elements that attract consumers (Chen et al., 2012). This research is based on Bloom's Taxonomy's use of EGM as the understanding part of the design thinking model. Therefore, students will use the emanative thinking higher weight lower layer (CEI) items of

the three-layer hierarchical diagram as design criteria and use them as design references in the product innovation design process. The middle layer (OEI) is used as the evaluation standard to evaluate the design cases so that students can accurately grasp the consumers' demand and design evaluation standards.

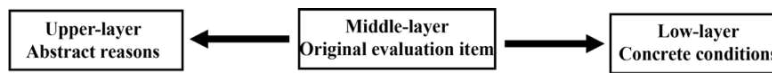


Figure 3. A three-layer hierarchical diagram.

2.3 Quantification Theory Type I (QTT I)

Quantification theory type I (QTT I) is a qualitative multiple regression analysis that involves categorical multiple regression analysis methods, which can be used for establishing the mapping relationship between the independent variable X and the dependent variable Y, and furthermore, for predicting the dependent variable Y (Hayashi, 1950). In previous studies, QTT I was used for analyzing the data generated by EGM, based on the credibility of set charming factors and the classification results and correlation index (Ho & Hou, 2015). The purpose of QTT I is to establish a relationship between adjective semantics and design considerations in order to find an approximate function of the variable of a purpose and other qualitative independent variables. Multiple regression analysis methods were used for detecting the intensity of each qualitative item's influence on the variable (Wang, 2009). Each qualitative variable contains several question items that can be used for establishing regression formulas. In this study, students need to converge the collected design elements and find out the design criteria the lower layer (CEI) with high weight through QTT I to help them clarify which special charming factors can be used during the creative design stage to catch consumer demand.

2.4 Function Analysis Method

Previous product design practices have proved that product innovation mainly involves the function analysis method and that it forms restrictions in the scheme design stage. Therefore, designers should focus on the functional analysis of product development. The definition of the function can broaden product innovation and seek out optimum ways for solving the problem. The function analysis method can confirm the basic functions and problem levels of a given product. This analysis method regards the system of the target product as a "black box." The left end of the "black box" is the "input" of function, and the right end of the "black box" is the "output" of the target that needs to be achieved (Cross, 1994). As shown in Fig.3, the function analysis process should not be limited to the original function system, which should reflect the overall function of the product as much as possible and expand the boundaries of the function system in order to improve the innovation of the target product. The detailed operation steps for function analysis are as follows: 1) According to "input" and "output," define the overall function of the black box and, as far as possible, enlarge the system border; 2) Decompose the overall function into a series of necessary sub-functions; 3) Draw a frame diagram of sub-functions to display the relationship between them; 4) Plan out reasonable system boundaries; and 5) Find suitable elements for realizing the relationship between the sub-functions (Lu & Hsiao, 2019). This study can discover the functional limitations of the target product through the functional analysis method, which can be combined with consumers' demand to enlarge the system border innovation product function, which encouraged students to consider whether the functional system met the design aims during the entire design innovation process.



Figure 4. Function "Black Box."

2.5 Form Restriction Method

Recent literature has shown that the modularization product framework can be applied in multiple ways (Stone, Wood, & Crawford, 2000). Hansen and Lenau (2013) provided the example of behavioral pattern analysis and manufacturing analysis performed by a student team after detaching bicycle gear when participating in a workshop. Students team created a geometric flow chart describing how the bicycle bell would be used. For the team, the most important part when creating a flowchart was identifying individual components and inferring an assembly sequence that confirmed the material and craftsmanship of each component. Furthermore, the most significant element was the practical experience of using these

components. For example, using the weights and temperatures of the hand.

The product model structure follows the modular approach proposed by Sellgren (1999), which treats technology as a medium between components and junctions. The component expounded the contact between the function surface and the product form structure. A modular structure can facilitate the modification of the product model structure (Sellgren & Andersson, 2005). The diagrammatic rules of the product during the redesign process are shown in Table 2. The internal product for indicating one big part has more than one function. Alternatively, one large part can be divided into several parts. It includes two different geometric figures and lines. The external product focused on the circumstance of the contacted part. It also includes two different geometric figures and lines. The overall flowchart of the process forms a restriction method. Students can use diagrammatic rules for disassembling the analysis and for understanding the structure and model of the product. Students can also find the demerits of the selected product from the flowchart while redesigning the product. This study used restrictions in order to analyze the existing product model and structure, find the problems of product structure, and optimize the solution scheme.

Table 5. Diagrammatic rules

Internal	Legend	External	Legend
Moving part		People/body in contact with a part, Ex: hand, foot, eye, etc.	
Non-moving part		Object in contact with a part, Ex: orange, material, water, etc.	
In contact with an internal part		Surroundings in contact with a part, Ex: floor, table, hanger, etc. In contact with an external part.	

2.6 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) was first proposed by Saaty in 1980; its main purpose is helping decision-makers select the best solution in an environment characterized by multi-criteria decision making. AHP is a multi-objective analysis method that combines quantitative and qualitative analysis; it can obtain the comparative weight of various options through pairwise comparison and then achieve the evaluation effect (Kubler, S., Robert, J., Derigent, W., Voisin, A., & Le Traon, Y., 2016). The operating pattern of the AHP involves decomposing a complex problem and constructing multiple levels. Participants indicate their overall preference for each decision option, calculate the relative weight of any alternatives and obtain a ranking (Aguilar-Lasserre, A. A., Bautista, M. A. B., Ponsich, A., & Huerta, M. A. G., 2009). Participants actively communicated and reached an agreement by discussing their providing subjective experience, thus ensuring the rigor of the evaluation results. The main operation steps of AHP are described as follows.

- Define the decision problem: First, confirm the purpose of the decision-making problem and then list all evaluation criteria and alternatives.
- Building hierarchical analysis: Resolve complex problems by deconstructing them into multiple hierarchical structures. The first layer is the main goal, the second layer is the evaluation criteria, and the last layer is the alternative. The evaluation criteria are used for evaluating all alternatives, and the evaluation criteria are weighted at the final stage.
- Construct a paired comparison matrix for evaluating the criteria: According to the advice of experts, compare the criteria in pairs and use the nine-point scale in Table 3 to create a decision matrix.
- Obtain the relative weight of the evaluation criteria. There are many ways to calculate weights. For instance, the eigenvector method (EVM), weighted least squares method (WLSM), theoretical analysis, and the geometric mean method. The geometric average method used in this study has high accuracy.
- Consistency testing: The execution result is verified by calculating the Consistency Relation (CR) when the weight of the evaluation criteria is obtained, as shown in Equation (1).

$$C.R. = (C.I.)/(R.I.) \quad (1)$$

$$C.I. = (\lambda_{max} - n)/(n - 1) \quad (2)$$

Table 6. AHP scale of 9 points used in the paired comparatives (Satty, 1980)

Comparison intensity	Comparison intensity
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important
2,4,6,8	Intermediate judgment values

In practice, the accuracy of the weights is determined by decision-makers. where CI is the consistency index, RI is the random index (see Table4), n is the order of the matrix, and $\lambda_{\max}$ is the largest eigenvalue of the matrix. The CI of the research problem is compared with the average RI obtained from the n-order random matrix to measure the error caused by the inconsistency. The concordance ratio (CR=CI/RI) when CR<0.1, or less, indicates that the judgment matrix is acceptable; otherwise, the paired comparison matrix should be modified (Satty, 1980). This study based on consumer demand, product function analysis, and structure analysis, students applied design criteria to design product cases and establish the alternatives comparison matrix of evaluation criteria through AHP to help students evaluate alternatives and choose the best solution.

Table 7. Table of random indexes

Number of criteria (n)	2	3	4	5	6	7	8	9
Random index (R.I.)	0	0.58	0.90	1.21	1.24	1.35	1.40	1.45

3 Implementation procedures of the new design thinking model

The design thinking model based on Bloom's taxonomy was divided into six stages. The detailed implementation steps are as follows. The specific process framework is shown in Fig.4.

Stage 1 (Remembering): Students create a design group of 3-5 people in order to construct an information table about the target product through an online survey; next, they use the established information table as a stimulus sample for the subsequent in-depth interview.

Stage 2 (Understanding): First, the design team uses the function analysis method to clarify the functional system of the target product (understand the functional attributes of the product). The form restriction method is then used for analyzing the structure and form of the target product (understand the appearance properties of the product). Furthermore, the evaluation grid method is used for conducting in-depth interviews with professional users in order to acquire a three-layer repertory map (understand the users' demand).

Stage 3 (Applying): First, students set up a questionnaire with a three-layer repertory map. After that, quantification theory type I is used for analyzing the results of the low-layer (CEI), thus obtaining a set of high weight design criteria as attractive factors with reference values. Finally, a group of alternative schemes is designed based on the analysis results of quantification theory type I, function analysis method, and form restriction method.

Stage 4 (Analyzing): The middle layer (original evaluation item) in the three-layer repertory map is used as the evaluation criteria, and the AHP is used for determining the importance of each evaluation index (evaluation criterion).

Stage 5 (Evaluating): Students uses evaluation criteria to evaluate alternatives and accordingly obtains a priority order for the alternatives.

Stage 6 (Creating): Diversified market demands are satisfied from the perspective of color matching and material innovation redesign.

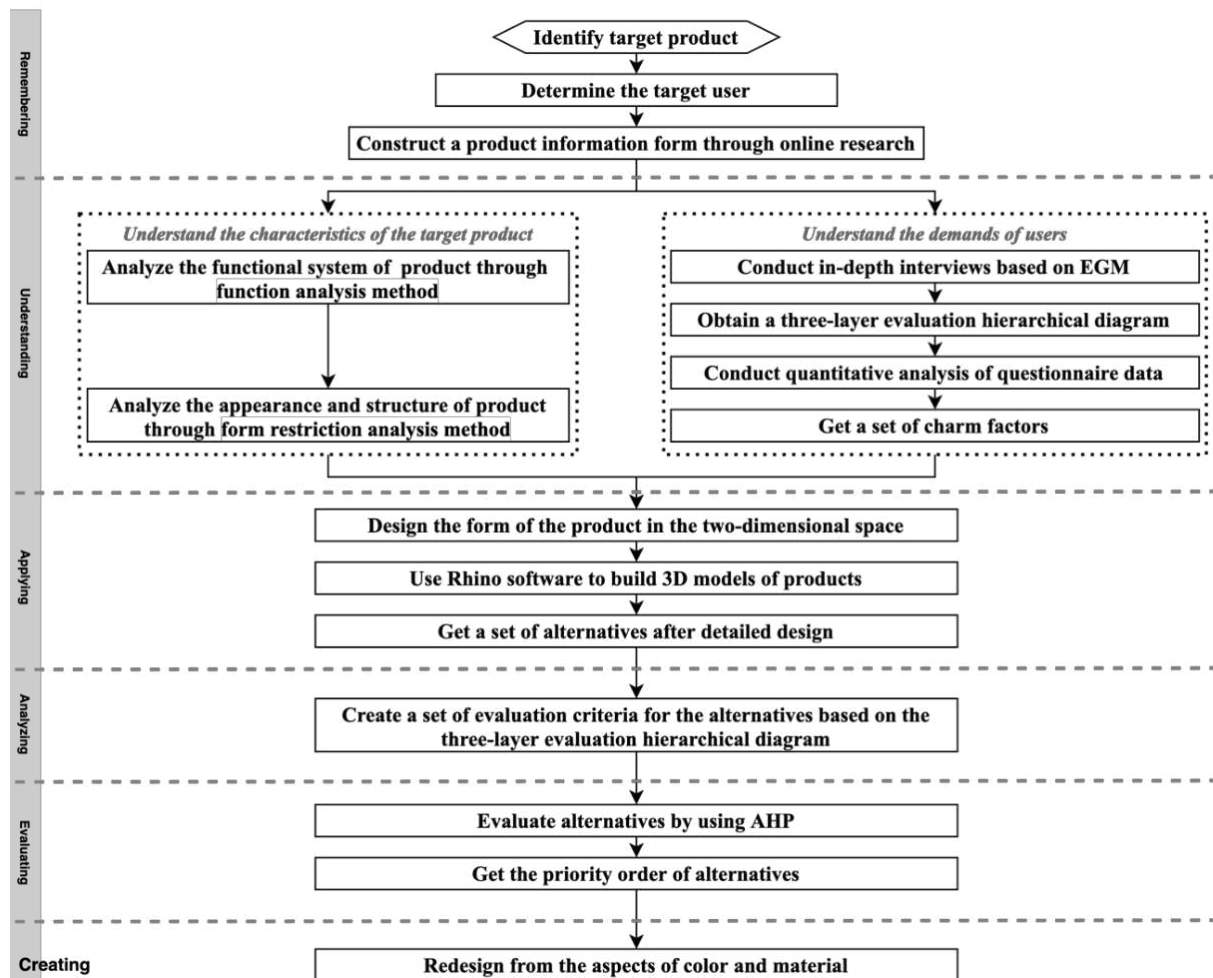


Figure 5. The new design thinking model based on the Bloom's Taxonomy.

4 Case study on classroom teaching

In course teaching, teachers usually suggest that students complete the product design in a cooperative manner with three to five other people. Team members work together to ensure the progress and quality of the design process. This study took a set of children's highchairs as the teaching case in order to illustrate how the student team conducted design practice based on the six-step Bloom's Taxonomy design thinking model. The detailed implementation steps are as follows.

4.1 Stage 1: Remembering

The design team accumulated the relevant product information from different online retailers (e.g., Jingdong, Taobao, and so on); this included images, seat widths, weights, textures, and table sizes for the product. To ensure that the product sample would be representative, the students were required to select the goods having the highest sales volume as their research samples. Thirty samples were collected. After the group discussion, similar and unrepresentative samples were deleted. Finally, six highchairs from different brands were included within the interview sample (as shown in Table 5). Team members sort out and remember product related information of different brands.

Table 8. Information about the target product

Brand model	China <i>Henryrabbitt</i>	America <i>Babycare</i>	Japan <i>Farska</i>	Netherlands <i>Zaaz</i>	Denmark <i>Kadi</i>	Italy <i>Chicco</i>
Product images						
Seat width/ mm	340	500	460	290	310	470
Weight / kg	13	8.5	8	10	4	10.5
Texture	Wood	PLA/Fabric	Wood/Fabric	AL/PLA	PLA	SUS/PLA
Table size / mm	480	520	470	400	350	450

4.2 Stage 2: Understanding

4.2.1 Analyze product features through function analysis method

Use function analysis method was made to black-box the functional system of highchairs and broadened the functional system's boundary, as shown in Fig.5. The input end of the functional system was "A baby ready seat," and the output end was "Baby after dinner," which comprised several sub-functions. The functional system of the highchairs obtained by the functional analysis method was divided into two types: foldable and non-foldable. Therefore, team members understood the functionality of the target product.

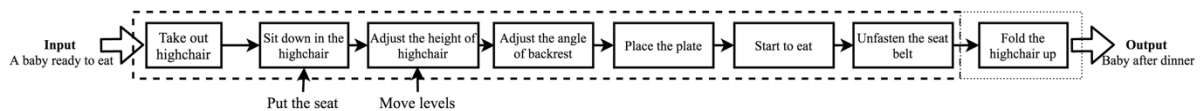


Figure 6. The function analysis of highchair.

4.2.2 Analyze the product model through form restriction analysis method

First, the design team deconstructed the form and structure of the highchair and inputted this information into a visual flow chart; furthermore, the team used different geometric figures to represent each component's connection mode. The design team then analyzed the visual flow chart of six products (see Fig.6), in which the numbers 1-6 represented the problems that required improvement. Subsequently, the design team discussed in detail how to solve each problem found, which can be better understand the form and structure of the product.

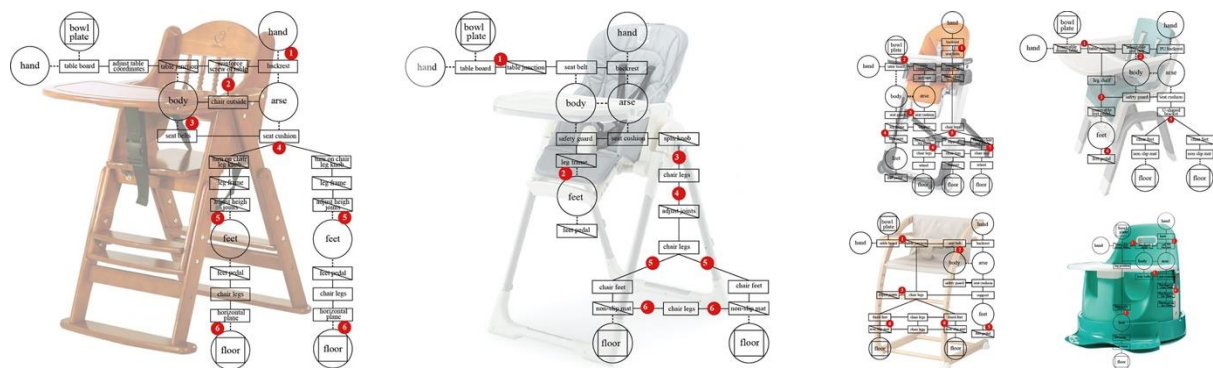


Figure 7. Form restriction analysis of highchair.

4.2.3 Identify the interviewees and conduct in-depth interviews

The team members invited and interviewed experts and staff members from baby stores. With each member inviting two interviewees, 10 interviewees participated in the study (four men and six women). Before the interview, students were required to introduce the product card and information table to the interviewees (see Table5). After the interviewees understood the samples and then compared them based on experience;

Students and interviewees conducted in-depth interviews where they explained whether interviewees liked it and why interviewees liked it. First, students learned the merit features of the product based on the interview content; this could be used as the original evaluation item (middle layer). The interviewees were then guided to answer the abstract reason (upper layer) and concrete condition (lower layer). Furthermore, the entire interview process was recorded to avoid any "missing information" situations. During the interview, one or two members were responsible for asking the questions, and the other members were responsible for recording the questions and ask the questions. After the interview, the students sorted out a three-layer hierarchical diagram that had a higher frequency of mentions. There were three upper layers, eight middle layers, and twenty-one lower layers in the three-layer hierarchical diagram (see Fig.7). Students regard the middle layer as an evaluation criterion. In addition, the attractive factors with high weight in the lower layer are regarded as important design references. In order to further clarify the degree of importance of the charm factors, it is necessary to invite more users to conduct QTT I questionnaire survey.

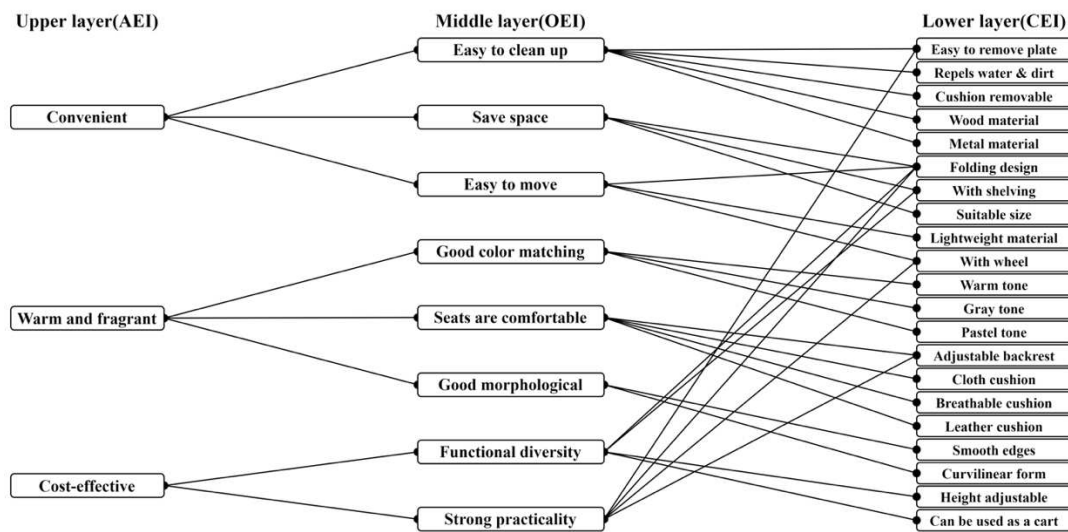


Figure 8. Interview: A three-layer demand chart form.

4.2.4 Questionnaire survey and quantitative analysis

An online questionnaire was created based on the three-layer hierarchical diagram. For the three abstract reasons (AEI), the original evaluation item (OEI) was used as the topic, and the concrete condition (CEI) was used as the option. The team members distributed the questionnaires online. A total of 83 questionnaires were collected, of which 70 were valid https://doi.org/10.21606/drs_lxd2021. Then, the students analyzed the questionnaire data using QTT 1 to clarify the degree of influence of the lower layer on the middle layer. We set the low-layer (CEI) as the independent variable X and the middle layer (OEI) as the dependent variable Y. The relationship between the two was established through multiple regression analysis, and the analysis results of this process are shown in Tables 6–8. The coefficient of determination (R^2) represents the reliability of the analysis results, the partial correlation coefficient represents the contribution of the middle layer to the upper layer, and the category score represents the contribution of the upper layer to the lower layer. The largest category score was formed by the eight items in Tables 6-8, regarded as a reference for design indicators. During the design stage, the students tried their best to use the eight high weight indexes in the lower-layer for product design. In addition, the OEI (middle layer) was more concrete than the AEI (upper layer) and CEI (lower layer) in the three-layer hierarchical diagram. Moreover, the eight middle layers were more suitable as evaluation criteria.

Table 9. The result of QTT1 regarding convenient

Feeling	Item	Category	Category Score	Partial Correlation Coefficient
Convenient	X1 Easy to clean up	Easy to remove plate	0.397	0.364
	X2 Save space	Folding design	0.424	0.556
	X3 Easy to move	Lightweight material	0.513	0.426
	R=0.649, coefficient of determination(R^2) =0.421			

Table 10. The result of QTT1 regarding warm and fragrant

Feeling	Item	Category	Category Score	Partial Correlation Coefficient
Warm and fragrant	X1 Good color matching	Pastel tone	0.921	0.599
		Leather cushion	0.872	
	X3 Good morphological	Curvilinear form	0.561	0.491
	R=0.709, Coefficient of determination(R^2)=0.503			

Table 11. The result of QTT1 regarding cost-effective

Feeling	Item	Category	Category Score	Partial Correlation Coefficient
Cost-effective	X1 Functional diversity	Height adjustable	0.508	0.693
	X2 Strong practicality	Folding design	0.658	0.692
	R=0.824, Coefficient of determination(R^2)=0.680			

4.3 Stage 3: Applying

4.3.1 The space layout of the highchair

The innovative design highchair had a 2D space layout. First, the function of the highchair was deconstructed into a series of sub-function units, including the support unit, load unit, linkage unit, protection unit, and operating unit, and it was represented with different geometric figures. Subsequently, innovative design of 2D space layout based on the design indicators of the high weights lower layer in the EGM, the geometric figures that created different space layout schemes obtained four space layout schemes (see Fig.8). Each space layout scheme had its own innovation, which was embodied in Layout 1. The front of the operation unit and the back of the protection unit were connected through. In Layout 2, the protection unit and the support unit were connected horizontally, and in Layout 3, the linkage unit was situated above the load unit. In Layout 4, the linkage unit and the support unit were connected up and down to the stretchable. Students analyzed the space layout of the highchair; this activity not only improved students' cognition of the product's form and structure but also helped those with feeble sketch skills improve their skills. Thus, it opened their thinking about innovative models.

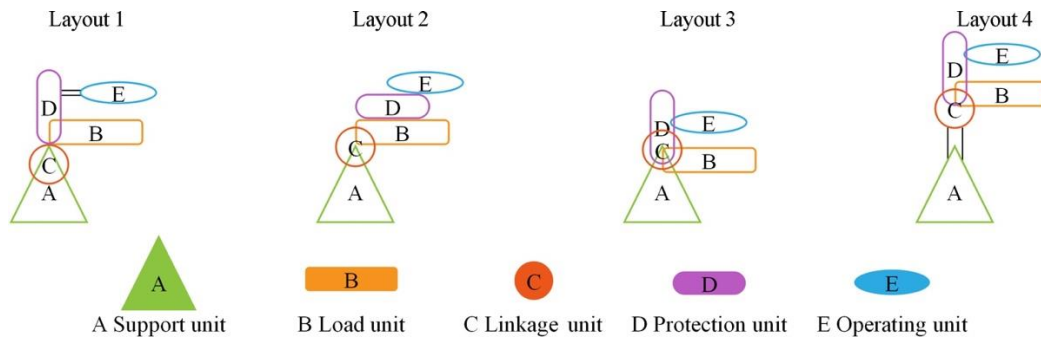


Figure 9. Four space layout case design.

4.3.2 Use rhino software to build rough product models

In accordance with the 2D space layout schemes, the team members used the Rhino 3D software to draw the preliminary model design and obtained four 3D schemes, as shown in Fig.9. Concepts 1-4 were optimized based on the four space layouts in Fig.8, which improved the pain points found using the form restriction method. Concept 1 combined Layout 1 and Layout 4, where chair legs could be stretched. Concept 2 was a combination of Layouts 2 and 3, where the linkage and load parts were up and down. Concept 3 was a combination of Layouts 1 and 3, and the connections between the dining table and the protection parts were detachable. Finally, Concept 4 was a combination of Layouts 2 and 4—protection and linkage parts in a horizontal state.



Figure 10. 3D model of highchair.

4.3.3 Alternatives concepts

Based on the four conceptual designs, the design team created some detailed designs and produced three alternatives, as shown in Fig. 10. To be specific, the attractive factors used in Alternative 1 included “Easy to remove the plate,” “Folding design,” “Pastel tone,” “Leather cushion,” “Curvilinear form,” and “Height adjustable.” The shape design referred to Concept 1. The attractive factors used in Alternative 2 included “Folding Design,” “Lightweight Material,” “Pastel Tone,” “Leather Cushion,” and “Curvilinear Form.” The shape design referred to Concept 2. The attractive factors used in Alternative 3 included “Easy to remove the plate,” “Wood material,” “Folding design,” “Leather cushion,” and “Height adjustable.” The shape design referred to Concept 3.



Figure 11. Three alternatives for the highchair design.

4.4 Stage 4: Analyzing

The eight middle layers (OEI) in the three-layer hierarchical diagram were used as the evaluation criterion of the design scheme (see Fig.11). The design team established a paired comparison matrix of eight evaluation

criteria and invited experienced designers and users to score the matrix. Then, the geometric average method was used to analyze the relative weight of each evaluation criterion (see Table 9), and the results showed that the weights of the D, E, and H evaluation criteria were obviously greater than the others. Finally, the team members used the Excel software to test the consistency results. The operation steps were simple and easy to understand. The students obtained the following results through Excel analysis: $CI = (9.091 - 8) / 7 = 0.156$, $CR = CI / RI = 0.082 / 1.41 = 0.058 < 0.1$. Accordingly, the pairwise comparison matrix was acceptable.

A Is it easy to clean	B Dose it save space	C Is it easy to move	D Whether the color matching is beautiful	E Whether the seat is comfortable	F Whether the shape is beautiful	G Whether the function is diverse	H Whether the product is pratical
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Figure 12. Eight evaluating criteria.

Table 12. The paired comparison matrix of 8 evaluating criteria

	A	B	C	D	E	F	G	H	Geometric mean	Weight(W)
A	1	0.333	0.333	0.143	0.111	0.333	1	0.200	0.323	0.029
B	3	1	3	0.200	0.143	1	0.333	0.333	0.641	0.058
C	3	0.333	1	0.200	0.143	0.333	0.333	0.333	0.425	0.039
D	7	5	5	1	1	3	3	1	2.510	0.227
E	9	7	7	1	1	5	5	3	3.672	0.332
F	3	1	3	0.333	0.200	1	1	0.333	0.818	0.074
G	1	3	3	0.333	0.200	1	1	0.333	0.818	0.074
H	5	3	3	1	0.333	3	3	1	1.846	0.167

4.5 Stage 5: Evaluating

4.5.1 Analytical hierarchy process evaluate alternatives

The goal of the design was selecting an optimum scheme from among the alternatives. The design team should therefore apply an evaluation criterion for evaluating the three alternatives. The design team built a pairwise comparison matrix of eight evaluation criteria and invited experienced designers and users to make pairwise comparisons and scores. The weight of the pairwise comparison matrix and the consistency result (see Table 10) were calculated using Excel, and eight pairwise comparison matrices were judged to be acceptable according to the CR.

Table 13. The paired comparison matrix of alternatives under the selected criteria

	A	B	C	D	E	F	G	H
Weight (alternative 1)	0.637	0.258	0.258	0.731	0.731	0.731	0.637	0.279
Weight (alternative 2)	0.105	0.637	0.637	0.081	0.188	0.081	0.105	0.072
Weight (alternative 3)	0.258	0.105	0.105	0.188	0.081	0.188	0.258	0.649
C.R.	0.033	0.033	0.033	0.056	0.056	0.056	0.033	0.056

Through the pairwise comparison matrix of the evaluation criterion, the students obtained a judgment matrix α for all the alternatives (see Table 10) and a weight matrix β for the evaluation criterion. Therefore, the significant ranking of the three alternatives was indicated by S , and the calculation results were as follows.

$$S = \alpha \cdot \beta = \begin{bmatrix} 0.637 & 0.258 & 0.258 & 0.731 & 0.731 & 0.731 & 0.637 & 0.279 \\ 0.105 & 0.637 & 0.637 & 0.081 & 0.188 & 0.081 & 0.105 & 0.072 \\ 0.258 & 0.105 & 0.105 & 0.188 & 0.081 & 0.188 & 0.258 & 0.649 \end{bmatrix} \cdot \begin{bmatrix} 0.029 & 0.058 & 0.039 & 0.227 & 0.332 & 0.074 & 0.074 & 0.167 \end{bmatrix}^T = \begin{bmatrix} 0.600 \\ 0.171 \\ 0.229 \end{bmatrix}$$

In summary, the significant ranking of the three alternatives was as follows: Alternative 1>Alternative 3>Alternative 2. The results showed that Alternative 1 was the best design scheme (Fig. 12). This design scheme adapted the lower-layer design factors in the three-layer demand map, including “Easy to

remove the plate,” “Folding design,” “Pastel tone,” “Leather cushion,” “Curvilinear form,” and “Height adjustable.” Based on the scientific judgments of the users and designers, it was the optimum scheme because it satisfied users' demands, was perfect in terms of function, and satisfied the requirements for beauty of form.



Figure 13. Obtain optimum case.

4.6 Stage 6: Creating

4.6.1 Product design

To meet the diversified market demands of users, the team members selected the best scheme as an example for implementing their detailed design. According to the CEI of the three-layer hierarchical diagram that suggested that higher frequencies are material and color factors, the best scheme for redesigning. In terms of color matching, students found eight popular colors in 2021 through online research. The main color was yellow (Fig. 13). The design team used popular colors to redesign the best schemes (see Fig. 16).

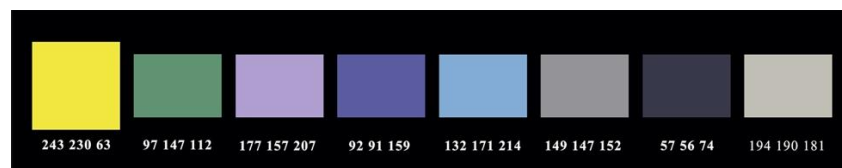


Figure 14. Eight popular colors found in 2021.

In terms of material, team members found four popular materials by analyzing existing products and CEI of the three-layer hierarchical diagram: plastic, wood, metal, and leather (Fig.14). Students used different materials and vogue colors to create innovative designs (Fig.15). Six different schemes were produced.

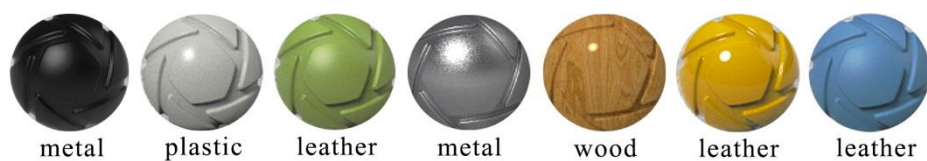


Figure 15. Four widely used materials.



Figure 16. Innovative design for product color and material.

5 Conclusion

Considering that the current design thinking models (DTMs) focus on how to improve the innovation of design activities but ignore how to help students understand the characteristics of the target product and the real

demands of users. Therefore, this article proposes a new DTM with two levels based on the six steps of Bloom's taxonomy, namely low-level consideration and high-level consideration. Low-level consideration includes three stages, namely remembering, understanding and applying. Remembering stage: Students sort out an information form about the target product through online research. Understanding stage: First, students adequately understand the product's inherent characteristics by using the function analysis method and the form restriction method. Then, students fully understand the demands of users by using the evaluation grid method. Applying stage: Based on the information obtained in the remembering and understanding stages, a set of alternatives is designed. High-level consideration includes three stages, namely analyzing, evaluating and creating. Analyzing stage: Based on the remembering and understanding stages, students draw up a set of evaluation criteria for evaluating alternatives. Evaluating stage: According to the evaluation criteria, an optimal solution is selected by the AHP. Creating stage: Redesigning from the perspective of color matching and material, thereby enhancing the creativity of the solution. The characteristics of the proposed DTM are as follows: 1) this DTM is a gradual and progressive process, that is, the latter stage depends on the previous stage; 2) This DTM provides students with effective methods at each stage, and these methods can be regarded as an innovative toolkit; 3) The methods provided in the understanding stage can not only help students understand the functional system and configuration of the target product, but also help students understand the potential demands of users; 4) During the interview process, students have to communicate face-to-face with professional users or sales staff of the product, so this process cultivates students' communication and expression skills; 5) The Excel provided to students during the evaluating stage can help students quickly obtain the priority order of alternatives. In conclusion, the DTM based on Bloom's taxonomy can help students to carry out design activities step by step so as to obtain the accurate functional system, reasonable structural configuration, and beautiful form and color matching. Finally, design the best solution that meets the real demands of users. In other words, the proposed DTM enhances the possibility of transforming the conceptual design into commodities. In addition, this DTM can help design educators follow Bloom's Taxonomy's six steps to teach students emanative and designated thinking. Students can accurately understand consumers' demand and product pain points, innovate product design according to design reference criteria, and use evaluation criteria to evaluate the plans. The new model is not only suitable for design educators to promote in the curriculum but also suitable for design students to constantly try in the design process.

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FIDS for Kids: Empowering Children through Design

A workshop on Design for Change's take on design thinking in education

Ruthie Sobel Luttenberg and Natalia Allende

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This workshop is designed as a theoretical-practical tool for educators and parents to understand how to take the Design for Change methodology to the classroom and beyond. Chosen by the United Nations as one of the 10 initiatives around the world that will allow humanity to reach the global development goals, Design for Change offers a simple, flexible, practical, and meaningful tool inspired by design thinking in the classroom setting with children of any age from 7 to 18. The presenters will offer attendees a theoretical approach to the mindset and spirit behind the Design for Change methodology (<https://www.dfcworld.org/SITE>), as well as a hands-on experience of this tool that allows for children to become empowered *with* their communities, solving real-world problems with concrete solutions while developing their I CAN mindset.

Keywords: design for change, student empowerment

FIDS for KIDS: a theoretical-practical workshop for educators

Often, educators want to bring innovative tools into their classroom but don't know how. Some educators have come to understand that design is a valuable tool for education (Carroll et al., 2010; Goldman & Kabayadondo, 2017; Koh et al., 2015) but feel overwhelmed by the challenge of adapting their practices to a tool that seems too far ahead of current standard practice (Henriksen et al., 2017; Jordan, 2016). Parents also want to offer experiences to their children that will help them to engage with their surroundings from an active and civic-minded standpoint. *FIDS for KIDS: Empowering Children through Design* is a workshop designed to help educators and parents understand and apply a simple methodology, inspired by design thinking that will allow them to introduce design to children in order to empower them to become agents of change in their own community (Bravo, 2016). The FIDS methodology by Design for Change allows parents and educators, who may or may not have experience in design thinking or similar methodologies, to bring their students/children into the design mindset with a methodology that is simple, direct, agile, empowering and impactful (Allende, 2016 a, 2016 b; Sobel, 2016).

Through the FIDS methodology (figure 1), comprised of four simple steps that the acronym stands for: Feel, Imagine, Do and Share, children have the opportunity to identify situations in their own environment that bother them or that they believe should be taken to a better state. By gaining in understanding of the situation and the motivations and experiences of all involved, they will be capable of designing attractive, sustainable, simple, and effective solutions to take this situation to a better place, maintaining the beneficiary or user at the center of their solutions. This extremely adaptable methodology develops skills and values as important as empathy, collaboration, critical thinking, effective communication, and creative problem solving.



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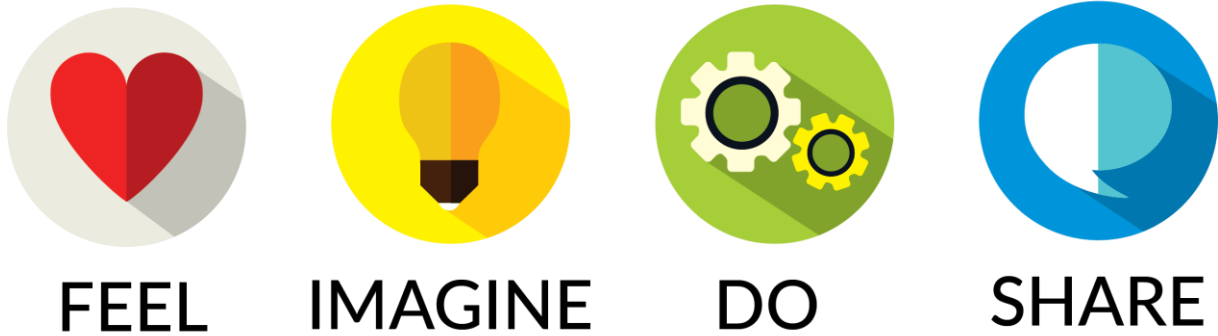


Figure 1: The FIDS process: Feel, Image, Do and Share

Intended audience and general flow of the workshop

This 60-minute workshop will be held 100% online for a minimum of 8 participants, ideally 12 participants minimum, and a maximum of 25 due to the interactive nature of some of the activities. The intended audience for this workshop is any adult that works or would like to work with children, such as schoolteachers with little or no experience in design, designers working with children who would like to introduce a simple and more accessible method for students, or even parents who would like to offer their children a way to approach the world from a creative and engaged manner.

Broadly speaking, the activities will alternate between theory and practice, allowing participants to understand the methodology and the mindset behind it, as well as experiencing parts of the process that will allow the educator to make a smooth transfer of the methodology to the classroom setting, regardless of whether this is online or in-person. Through the interactive workshop activities, the participants will interact with each other as they experience some of the FIDS methodology by going through each step or observing experiences by groups of children. By the end of this workshop, educators will have a better understanding of the mindset and process of the FIDS methodology and how its application in the context of school and beyond will empower children through the experience of creative problem-solving in the face of their own reality, always fostering the skills and values mentioned above.

Why is this workshop valuable to educators and adults who work with children?

Design for Change's FIDS methodology is considered one of the most innovative in education as it is highly accessible for school teachers of any field. Its simple methodology makes it approachable because, as we always say in Design for Change, it's not rocket science! FIDS is a methodology for every child, developing multiple social-emotional skills while also instilling what we call the I CAN mindset in students. Though a demanding process, it is fun and helps students become positive and active members of their community, in school and beyond. It also serves as a direct gateway to understanding and engaging with the Sustainable Development Goals (SDGs).

General Plan

Activity	Description	Activity	Duration
Ice-breaker	Getting to know you.	Make a name tag decorated in a way that tells us a bit about yourself	5 mins
Intro to FIDS for KIDS	Presentation of what is at the core of the Design for Change methodology and how it can impact the learning process. Results of the initial research exercise performed by Harvard's The Good Project. General information here: https://www.dfcworld.org/file2015/research_2.pdf	What is DFC: Movement/Method/Mindset	10 mins
FEEL practical exercise and critical analysis	Presentation of the main elements and actions that make the Feel stage of the FIDS process effective and meaningful.	WE the People STGs Out of the 17 global goals which one would you most like to address? Write on a piece of paper and hold it up to the screen. The one chosen by most will be the one we address.	10 mins
IMAGINE practical exercise and critical analysis	Exercise applying the main characteristics of the brainstorming process from the design methodology and how to take it to the classroom.	Define: What about this problem is most challenging? (Facilitator will make a list on a common board (Lino/padlet or Jamboard) The participants will be asked to come up with 4 solutions that use their: Hands/Feet/Hearts/Minds	10 mins
DO practical exercise and comments	Presentation on how to plan an effective action plan and practical exercise.	Now qualify each solution with one practical action you could take to execute your solution	5 mins
SHARE foundations for good video story-telling. Theory and practical exercise	Observation of some stories of change carried out by children from around the world. Focus on the effectiveness of the message and elements implied in the digital production of the story.	Show DFC environmental intervention stories. Some good/ some poorly done and have the group discuss the impact of a story well told as to one that is not	10 mins
Reflection	Feedback and group reflection	Write on common board: Something that moved you An insight Next steps	5 min
Conclusions and closing remarks	General closing comments and questions and evaluation.	FIDS for KIDS: An algorithm for empowerment.	5 mins

Materials needed:

- paper
- pen/pencil
- colored pencils or markers.

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Workshop: How to Design to Improve Life

Compass, a problem-solving tool by The Index Project

Catalina Cortés and Mariano Alesandro

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The current context derived from the Covid-19 pandemic has abruptly modified what we knew as “the education system” globally. If before education was located mainly in the classroom, today the hybrid modality makes educational dynamics more complex and must focus on the development of critical thinking skills to foster autonomy and problem-solving abilities in teachers and students. Educators more than ever need to prepare students to work and thrive in an unknown future scenario. Professionals in the future will need to lead sustainable innovation by considering the long-term implications of their design solutions in every field. This workshop is an introduction to the Compass® methodology developed by The Index Project®. The Compass is a flexible frame of action to organize, structure, and manage problem-solving processes. The difference between this method and other design thinking models is its focus on maintaining coherence between form, impact, and context in every phase of the design process to evaluate solutions holistically and sustainably to improve people’s lives.

Keywords: Design thinking, problem-solving methods, Compass methodology, design to improve life

Introduction

There is ample literature that suggests—to a higher or lesser extent—that not only design professionals—but everyone—designs in their daily lives (Simon, 1996; Schon, 1987). In the field of education, the “design thinking” process has been used as a structure to guide teachers when exploring educational problems that they face daily (Henriksen et al., 2017, Jordan, 2016). This has happened in part because the skills and mindsets that designers develop throughout their practice such as flexibility, uncertainty management, and the ability to face open problems and ideate possible solutions (Cross, 2001), are also fundamental for educators and young students. They are indeed considered fundamental 21st-century skills for any future professional (The Index Project, 2012). There are also some examples of design thinking models adjusted specifically for education as Design for Change, Henry Ford Learning Institute, and the Design Thinking for Educators guide developed by IDEO.

Nevertheless, complex problems and challenges of today’s world, also demand that any future professional approach problem-solving holistically (Andrews, 2015), orienting their thinking and practice towards more sustainable modes of production, and the development of critical innovation. LUTNÆS (2019), explains that critical innovation considers analyzing what situations require to change, the socio-ecological consequences of the intended change, and questioning who will benefit if a situation changes. Design models for sustainability, incorporate sustainable thinking in the resolution of problems, considering local needs, cultures, and ecosystems to produce adequate solutions. This approach leads towards developing ecological literacy (Orr, 1992), which is needed by the global population. This focus represents an “extremely complex sociological dilemma” that can lead to transform the values by which we live in the world (Stegall, 2006).

Although diverse design models have been developed to support designers evolve into a more sustainable practice: “Cradle-to-cradle” (Braungart, M., McDonough, 2002); Eco-design (Brezet, H. Van Hemel, 1997); The Circular Design Guide (Ellen Mc Arthur Foundation (EMF) and IDEO), which has proven to be an effective



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hands-on guide (Reigado, Fernandes, Saavedra, Ometto, & Da Costa, 2017), they are complex to use and mainly oriented towards product or service development. The Compass® methodology created by The Index Project®, on the other hand, is an easy-to-follow model of the design process that serves as a structure to organize and manage problem-solving processes oriented to create sustainable solutions that improve people's lives.

The Index Project® and the Compass® methodology

The Index Project®, formerly INDEX: Design to Improve Life®—born in 2002 in Denmark—is a Danish NPO with a global reach that inspires, educates, and engages people across educational levels, to design sustainable solutions to global and local challenges. The organization promotes the application of design and its processes to create better solutions in vital areas of the lives of people and communities worldwide. The development of their design approach is coherent with the actual globalized and knowledge-based world that demands different skills from those needed in the industrial traditional linear economy. Societies need critical, innovative, and responsible citizens who can ideate solutions for complex challenges using cross-disciplinary, user-centered, and sustainable processes, methods, and techniques applicable by everyone (not only by designers).

Although they agree on the relevance of Design Thinking and the creative methodologies connected to it as a means to provide future generations with the skills needed in the 21st century, they insist that mere design thinking is not enough. The Index Project® suggests that design methodologies must be deeply anchored in what the organization in 2002 coined as Design to Improve Life; a user-based design approach that ensures that the triple bottom line of economic, social, and environmental sustainability is always taken into account.

The Compass®

The Compass is the backbone of the learning initiatives by The Index Project®. It is a problem-solving tool that integrates the three fundamental competencies of didactics, process facilitation, and 'design to improve life'. Whatever the challenge or the educational level in which it is used, the Compass can help you get from A to B with concrete actions, methods, and techniques. It helps you navigate, focus and stay on track while encouraging curiosity, engagement, creativity, and innovative thinking.

It uses the parameters of FORM, IMPACT, and CONTEXT in four phases: prepare, perceive, prototype, and produce. In this way, fundamental aspects of the development of a design solution are covered such as function, potential, level of innovation, propagation, and economic, environmental, and social sustainability of the proposed design. In addition, it examines usability and cultural/geographical factors, specifically in the context where the solution will be implemented. Combined, these parameters assess the real possibilities of a design to improve people's lives.

FORM: evaluates the surface, material, interface, color, coherence, and aesthetics of the design.

IMPACT: is centered on the design's relevance and real potential to improve people's lives and economic and environmental sustainability.

CONTEXT: focuses on the context in which the design will be inserted, the relevance of the challenge, and the solution in the culture and geographical location in which it will be implemented.

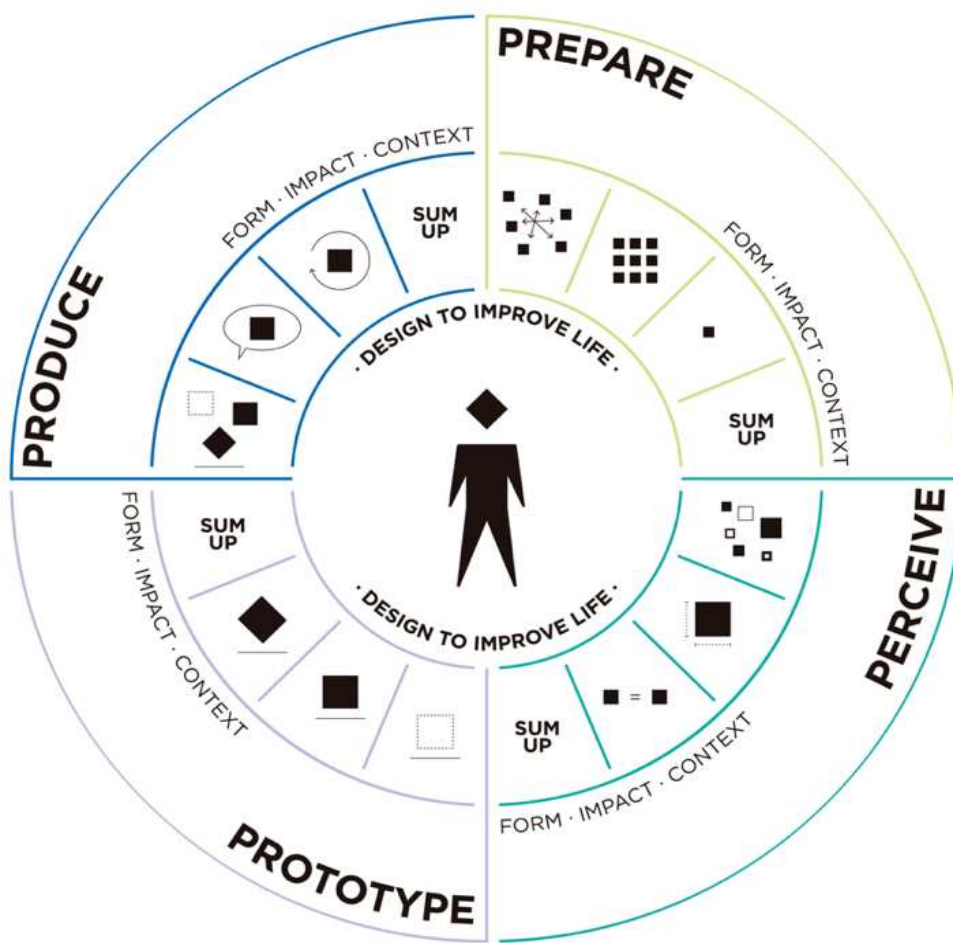


Figure 1. The Compass® (graphic summary of the four phases: Prepare, Perceive, Prototype, Produce)

Workshop: How to Design to Improve Life: Compass, a problem-solving tool by The Index Project

Workshop aims:

- Introduce the Compass as a flexible problem-solving tool.
- Describe the four phases through visual material and discussions.
- Revise a series of cases to assess coherence for sustainability.
- Disseminate the Compass as a frame of action to organize, structure, and manage problem-solving processes.

Workshop outline (120 minutes online):

We have conducted Compass workshops physically and online for various audiences: school teachers, university professors, designers, undergraduate design students, graduate master's students, and companies. In the case of this 120 min workshop, the difference between physical or online is mainly the working materials. Physically we would use worksheets, pencils, post-its, and simple prototyping materials. Online we will use Miro to work collaboratively in groups of 5-6 participants.

Table 1. workshop outline

TIME	Activity	Expected outcome
0-20 min	Check-In Icebreaker warmup greetings Group information	Get to know participants and expectations.
20-45 min	BRIEF INTRODUCTION TO THE COMPASS Introductory video Description of actions in each phase	General idea about the methodology and its phases.
45-60 min	REVISION OF CASES Assessing coherence for sustainability: The FORM-IMPACT-CONTEXT triad	Review of selected Index Awards winners and assess coherence in group discussions.
60-80 min	PRESENTATION OF RESULTS AND DISCUSSION	Each group explains its results and the whole group discusses.
80-90 min	BREAK	
90-100 min	THE FOUR LEARNING SPACES / Group Discussion	Reflect on the role of the instructor and/or facilitator in the 4 learning spaces.
100-120 min	SUM UP / OPEN DISCUSSION Wrap-up and check out	Final discussion.

Expected outcomes of the workshop:

- Understand the basic structure of the Compass.
- Experience a practical overview of fundamental aspects of the Compass.
- Produce fruitful interactions between participants.
- Understand the flexibility of the Compass as a frame of action to organize, structure, and manage problem-solving processes.

Minimum and maximum numbers of participants: 5/30

Participants will benefit from the workshop in the following:

- They will be introduced to a new methodology to apply with their students or co-workers.
- They will experience a collaborative activity with professionals from various backgrounds.
- They will be able to share their experiences within their group.

The workshop is relevant to the track's aims because:

- Although the Compass has been used in many different educational and professional contexts in Denmark and abroad, it is not known among the design research community.
- The Compass is a methodology that has been successfully implemented at school and higher education settings, it shares common tools with other design processes, but its sustainable standpoint is fundamental for future professionals.

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Section 02

Empowering Critical Design Literacy: Exploring Practices, Discourses and Implications in and Across Design Education from Kindergarten to PhD

Track 02: Empowering Critical Design Literacy

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Back in 1992, David Orr stated the need for an epistemological shift “...against the test of sustainability our ideas, theories, sciences, humanities, pedagogy and educational institutions have not measured up” (Orr, 1992, p. 83). Thirty years later, the need for a shift is ever more pressing—the Sustainable Development Goal Index 2020 reveals that major challenges remain (Sachs et al., 2020). How might design education empower the young generation to imagine society and everyday living differently, and to opt for sustainable design and responsible consumption? How might design education empower for ethical sensitiveness, transformative practices and to tackle wicked problems ahead?

The track call is a continuum of the DRS//Cumulus-conference 2013 with the overall theme *Design Learning for Tomorrow – Design Education from Kindergarten to PhD*. The Oslo conference in 2013 framed design education for all as a game changer: To promote sustainability and meet global challenges ahead, the professional designers are dependent on the critical and informed consumer—a design literate general public (OsloMet, 2013, Nielsen et al., 2015). Design Literacy is connected to both the creation and the understanding of design in a broad sense (DesignDialog, n.d.; Design Literacy International Network, n.d.; Nielsen et al., 2019; Nielsen & Digranes, 2012; Nielsen & Brænne, 2013; Research group Design Literacy, n.d.). Designers, policy makers, investors and consumers all make choices that influence future visual and material culture—the mitigation or continual growth of pollution, overconsumption and social inequalities (Lutnæs, 2017). What is it that the next generation of professional designers and a design literate general public needs to know and be able to do, challenge and discover to contribute to the large-scale changes needed facing the global challenges of climate change, loss of biodiversity and social inequality?

In track 02, we invited design researchers and educators to explore, and crack open *critical design literacy* as a subset of *design literacy*. At the core of *critical design literacy*, we suggested the ability to connect to real-world dilemmas with empathy, reject destructive products of human creativity and focus on problems that are worth solving. The main concern of the track is the exploration of current educational practices, academic discourses and implications of design education empowering for critical design literacy at a specific level of education or across levels (kindergarten to PhD). We provided some questions of interest as a starting point:

- How might design education provide an arena to question, rethink and transform current knowledge and cultural practices towards more sustainable ways of living?
- How might the abilities of critical design literacy be articulated for the general public and/or for the professional designer?
- What are the current academic discourses of critical reflection across levels of design education, or across fields of art, design, craft and technology?
- What distinguishes practices of critical reflection within the field of design compared to other disciplines (artists, engineers, craftsmen)?
- How does the role of design education change empowering for critical design literacy, what are the ethical dilemmas involved?
- What design briefs and exercises might support the development of critical design literacy?

Contributions to track 02

In their paper, *Hofverberg* and *Maivorsdotter* make the question of sustainable clothing a matter for critical



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design literacy. Specifically, they examine the meaning making of an educational material consisting of 17 design and craft projects produced for teachers in design and craft education by *The Swedish Consumers' Association*. The meaning making produced in the educational material provides certain norms and certain ways to act for the pupils. Hofverberg and Maivorsdotter contribute by articulating abilities of critical design literacy related to the topic of sustainable clothing. Two ways of becoming a sustainable consumer of fashion have been identified – to have fun and to feel clever – and these meaning making activities incorporate certain actions of what it means to be a sustainable consumer. The 17 design and craft projects are targeted to the pupils in general education. By analysing design briefs and exercises, Hofverberg and Maivorsdotter crack open the current outcome and invite researchers to discuss other possibilities towards critical design literacies. As we all wear clothes, the contribution of a general public that is capable of acting on clothing sustainability is substantial.

The potential of the research method Photovoice is explored in *ten Brink, Nach and Schouten's* paper on how to support design students' critical reflection. The authors frame critical reflection as a crucial skill for responsible design professionals and turn our attention to the challenge for design educators to turn reflection from an individual cognitive process inside a student's head into a social, tangible and preferably self-guided process in class. The paper draws upon an explorative user study with two cohorts of 3rd-year bachelor students in the Netherlands. The students explore given concepts by taking photos and the authors adapt the conventional steps of Photovoice to an educational setting that shifts the responsibilities from the educator to the students. The students are able to express interpretations. However, they need more support to relate their interpretations to beliefs, values and internal loyalties' and make complex connections. *ten Brink, Nach and Schouten* construct five frames from their empirical data to guide further exploration of the method. They suggest how the five frames might be translated into a set of frame cards as reflective triggers in Photovoice assignments. *Ten Brink, Nach and Schouten* contribute by exploring potential as well as boundaries related to how Photovoice as a design exercise supports critical design literacy.

Maus turns to the current academic discourse of design education in her paper. Her study is a conceptual review of three selected frameworks for promoting students' reflection in design education. The frameworks are described in recent research papers and *Maus* contributes by comparing and discussing their different focus of attention, steps and topics of reflection. Her review results indicate that the focus of attention affects the topics of reflection: the how-topics related to product design, the why-topics related to environmental impacts and the what-topics related to multiple solutions to challenges in both product design and environments. The three frameworks for reflection provide different contributions to enhance students' critical design literacy. *Maus* concludes that they all have the potential to support the students' capacities to operate within, question and transform their field of practice.

Noel challenges the traditional script of global social design projects by intentionally flipping the power dynamics of the collaboration. Her paper details a workshop for design students in which the students from the Global South had more decision-making power than the students in the Global North. They were the ones who would lead the discussion, 'diagnoses', and determine the preliminary design direction, and the Global North students had the roles as local consultants who served as a bridge between the foreign consultants and local culture. The context of the design challenge in the workshop was the culture of Silicon Valley. The students were introduced to ethnographic techniques and practices of critical reflection by examining bias and positionality. *Noel's* contribution to design education is twofold. First, she provides alternative models for international collaboration that disrupt unbalanced power relations from colonialism and the design saviour narrative in global social design projects. By this she inspires design educators to critically examine the design challenges they provide for their students, and the narratives that come along. Secondly, she details exercises on how future design professionals can be empowered for critical design literacy and reflect on power dynamics in international design work.

Lutnæs moves between different levels of educational practices as she works both as a teacher in lower secondary education and as a professor at the university. The study is set at the scene of lower secondary education and she maps out potential empowerment of critical design literacy within two of her design projects: *Repair* and *Ecovillage*. The empirical review examines ways in which pupils are challenged to question, rethink and transform unsustainable practices of everyday living. Both projects disrupt the commonplace habits of inevitable human practices: getting dressed and building shelter. In the *Repair* project, pupils design kits for mending clothes and suggest changes in both the fashion industry system and their own consumption patterns. The *Repair* project holds the potential of empowering pupils to navigate complexity and ethical concerns of fashion as consumers. In the *Ecovillage* project, pupils are challenged to claim a role as redirecive practitioners in the design process and discern the possibilities of architecture to nudge change in our modes of being in this world. By gaining first-hand experiences with design as a redirecive practice, pupils

unveil the vital roles and responsibilities of designers of coining visions and actions towards more sustainable ways of living.

Coda

The transition into a more sustainable model of society depends on citizens that act on their knowledge and design and implement large-scale changes. Looking back at the questions asked in the call, the contributions of track 02 articulate what critical design literacy means at specific levels of the educational system, for the next generation of professional designers and for a design literate general public. A shared concern of the papers is on how design educators might empower for critical design literacy. The papers contribute by exploring frameworks, briefs, educational materials and exercises. We hope to inspire the community of design educators to measure up against the test of sustainability and make changes that embed critical design literacy as a core part of their educational practices.

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Experiencing Sustainable Fashion: Have Fun and Feel Clever

A Case Study for Critical Design Literacy

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The consumption of clothes is increasing every year, which is a huge challenge for sustainability. Educational Design research have shown that the challenge cannot be solved unless we have critical literate consumers. By making the question of sustainable clothing a matter for critical design literacy, the aim of this case study is to examine the meaning making of an educational material produced for teachers in design and craft education. The educational material, entitled Sustainable Fashion, consists of 17 design projects and the analysis is made with the aid of practical epistemological analysis with a specific focus on aesthetic experience. Two ways of becoming a sustainable consumer of fashion have been identified – to have fun and to feel clever – and these two meaning making activities incorporate certain actions of what it means to be a sustainable consumer. From a critical design literacy perspective, these ways of becoming a sustainable consumer are crucial to acknowledge, as they include (and exclude other) specific sustainability actions.

Keywords: critical design literacy, sustainable clothing, fashion, educational material, Craft and Design Education

Introduction

Clothing production is a major problem for sustainability. For example, it has a huge impact on the environment through water use, pollution, waste and carbon emissions. The low prices on garments are also forcing negative social impacts for garment workers with unsafe labour conditions, low wages and long working hours. In short, the clothing production is not sustainable. Yet, clothes consumerism is increasing every year which is a huge challenge for sustainability and, as design researchers argue, the challenge cannot be solved unless we have critical and informed consumers (Nielsen et al., 2015). By making the question of sustainable clothing a matter critical design literacy, the aim of this case study is to study the meaning making of sustainable clothing in an educational material produced for teachers in design and craft education.

A number of Design Education researchers (Stegall, 2006; Fletcher, 2015; Lutnæs, 2019) have argued for the importance of acknowledging *the use* of designs and not only focus on the designs production. A key argument for designing for sustainability, put forward by Stegall (2006), is to “envision products, processes and services that encourage widespread sustainable behavior”. How we learn to behave with designs – also acknowledged as a design literacy – is however not a straightforward phenomenon. Rather there is a difference in both how and what one is becoming literate with. On this matter, Lutnæs (2019) identifies four narratives when designing for design literacy. The narratives acknowledge both the process, such as the making process or participating in the design process, and the outcome of what it means to be literate. Becoming literate, for example, is to be empowered for change and citizen participation or being able to address complexity of real-world problems. Accordingly, to design literacy can point both to the process and being able use designs. Fletcher (2015) also stresses the use of designs and in particular clothes literacy in terms of sustainable fashion. As fashion is so closely connected to consumerism, she argues that we need to “acknowledges the deep-rooted political and structural influence of the market and individualistic consumption on our ideas about fashion” (p.20), so we are able to see how it is influencing on us. Then, she continues, we need to stray outside this understanding where we can “re-appreciate the potential of fashion to nourish and foster other actions – to remake these charged political choices through our design and production decisions, through our wardrobes and as we dress” (p.20). In this way, we can, according to Fletcher (2015), broaden the agenda for



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fashion beyond production and consumption of new clothes.

Thus, the use in and of design are two core issues in Design Education research. But how are these matters taught when it comes to sustainable clothing? In this case study we are examining a particular educational material named *Sustainable Fashion*, which is produced by a Non-Governmental Organisation (NGO); Swedish Consumers' Association (SCA). The educational material has been widely spread in Sweden and is free to download on their website. On their website one can read about the purpose with the educational material:

Our idea with the educational material Sustainable Fashion is to start a discussion about textiles, clothing and sustainability in an engaging and creative way. We want to encourage and inspire young people to a more fun, smarter, more sustainable clothing consumption and we believe that it is through your teacher that we have the greatest opportunity to reach our message. (SCAa, 2017)

The purpose with the educational material, as it is stated in the quotation above, is to encourage and inspire young people to a more sustainable clothing consumption. In this case study, we aim to illuminate the meaning produced in the material. By examining the meaning making in the educational material, we will show in what way sustainable fashion is promoted and what actions that are possible to take in becoming a "sustainable consumer".

The case

The empirical data used in the case study is an educational material produced by a Swedish NGO *The Swedish Consumers' Association*. They are representing the Swedish consumer interests on national, regional and international level. The specific data that we explore consists of 17 design and craft projects that is designed for teachers to use when they education for to sustainable fashion (SCA, 2017). The analysis is made by using a practical epistemology analysis (PEA), which has been developed for the purpose of analysing the process of meaning making (Wickman, 2006; Wickman & Östman, 2002; cf. Hofverberg & Maivorsdotter, 2018). Four PEA concepts are used as an analytical framework: (1) end-in-view, (2) gap, (3) relation, and (4) encounter. The analysis is conducted as follows, using the four concepts:

In *the first step* (1), the ends-in-view in the educational material are identified (Dewey [1934] 2005). The ends-in-view is what the actions described in the educational material is directed towards, that is the goal with the activity. For example, the end-in-view to "feel clever as a sustainable consumerist" has been identified in the educational material developed by The Swedish Consumers' Association. This end-in-view opens up a gap between the fulfilment or not fulfilment of feeling clever as a sustainable consumerist.

The second step (2) in the analysis is to identify these gaps in the educational material. In order to fill this analytical gap, *the third step* (3) is to identify the various relations that are used in the text to fill the gap. Here, a relation that fills the gap refers to the statements or utterances that construe a connection between the entities of experience. The analysis only includes relations where aesthetic judgements are used showing the direction the meaning making is taking. Earlier studies (Maivorsdotter & Wickman 2011; Wickman 2006) have shown that people – in this case, the NGO who produced the text – make aesthetic judgements when making meaning of an experience that moves towards fulfilment (a positive aesthetic experience) or away from fulfilment (a negative aesthetic experience). For example, if the NGO makes the aesthetic judgement of "this will be perfect", they experience the action as moving towards the fulfilment of the ends-in-view. Aesthetic judgements thus provide the researcher with information about how the NGO judges the possibility to successfully become a sustainable consumer of fashion. For example, the relations such as "It is clever to only buy clothes that you actually need" show that being aware of one's personal preferences for clothes is an aesthetic experience leading towards the fulfilment of feeling clever as a sustainable consumerist. This can be understood as having a positive aesthetic experience as a consumer. In contrast, relations like "Buying clothes on impulse" lead away from fulfilling the end-in-view of feeling clever as a consumer and therefor is an example of a negative aesthetic experience.

In *the fourth step* (4), the encounters that are analytically constructed within the relations are described; for example, the relation of "It is clever to only buy clothes that you actually need" asks what encounters emerge in this relation. This can be both physical things, for example, garments, and also the mental aspects that might appear, such as someone's previous experience of knowing what a needed garment actually entails. The educational material from the NGO was analysed by the two authors, first separately and then together, where all the five steps were considered. The identified ends-in-view were then categorised. Steps one to four were elaborated during a workshop with researchers in education to confirm interpretations and conclusions. The two identified ends-in-view are presented below.

Findings

Drawing from the end-in-view step, two ways of making meaning of the sustainable consumer of fashion have been identified in the educational material, namely, *to have fun* and *to feel clever*. The meaning making that is produced in the educational material out lined below.

To have fun

The first category that could be identified as an end-in-view in the material is *to have fun*. Below will show the analyses with an example and then, the other ways that is directed towards the activity of having fun are listed. The first example points to the activity of visualising a dream jumper which is considered a fun activity:

In the activity, the pupils will work out what their dream jumper is and how it will look. They will visualise the jumper by drawing, cutting and pasting. Write on the board that they can think about colour, pattern, material/fabric, and possibly the brand. (SCAb, 2017, p.3)

The educational material also provides a number of questions and bullet points that the teacher should address as a starting point for a discussion:

What do we think about when we buy clothes? If we are going to go out and buy our dream jumper, how do we make sure the dream doesn't come crashing down? Ordinary shoppers are usually not able to really test clothes before buying, so it's good to follow some guidelines. Before we buy an item, it is useful to think about the following things in order to find clothes that will last:

- *How do I make the right choice?*
- *Stitching*
- *Material*
- *What are the washing instructions?*
- *Can it be mended?*

Write these points on the board and go through them, letting the pupils make suggestions about each point.

How do I make the right choice? How can one know if one will actually wear the item of clothing? To begin with, it is important to always try on an item of clothing before buying it, as it is often the case that it just feels right. Does the item look good and feel comfortable on the body? Think about what you need and what it will be used for. The item will need to have certain characteristics if you are going to exercise, like in the clip, or if you are going to wear it to school or to a party. Next to the picture of their dream jumper, have the pupils to write the context they can imagine wearing it in. (SCAb, 2017, p.3)

In the above, the pupils do not visualise just any jumper, but their *dream* jumper, which is considered as something fun. 'Dream' is identified as an aesthetic judgement and the *end-in-view* is to have fun. This end-in-view opens up a *gap* as to whether one is able to have fun or not. The relations that fill the gap, that is, whether one can have fun or not, are in the quotations that have been divided into three parts. First is to be able to visualise the dream jumper and thus design the dream. The *relations* that fill the gap is to draw the jumper, cut and paste, and have an idea of what the jumper looks and feels like in terms of colour, material, pattern, form and brand. Pointing to the second part of the text, to have fun also involves sustaining the dream so it does not shatter. The relations that fill the gap here is to have knowledge about the dream jumper in terms of how it is constructed, what it is made out of, how it should be washed and whether it can be mended. In the last part of the quotation, the relation that fills the gap is to know in what context the jumper is to be used. What the pupil is *encountering* in these relations is knowledge about materials, designing techniques, knowledge about personal preferences and knowledge about the social context one is taking part in. The other relations that emerge in this category with the end-in-view to have fun are stated in table 1.

Table 1. Shows the findings from “having fun”.

To have fun	Relations
	create a feeling of happiness without shopping
	make a clothes mob (where one garment is used by different people)
	to find your own style
	to feel for a garment
	to comment on politics through craft

In this first category, having fun is an end-in-view that it is used as an aesthetic expression when sustainable fashion is promoted. This in turn, encourages certain actions which includes certain ways of making meaning about sustainable clothing consumption (see table 1).

To feel clever

The other category that has been identified as an end-in-view is *to feel clever*. This category is larger, as we have identified 18 ways of feeling clever. We will present one example by using PEA and then list the other ways.

In the first example, the following passage in the “Sustainable Fashion” text points to feeling clever when one buys clothes that last, even though they may be more expensive. The project that the pupils are suggested to do involves half of the class making a bag based on quality (i.e. making it so it will last) and half the class is to make a bag based on quantity (i.e. making as many as possible). After the activity, the class is meant to discuss the results of the activity:

Discuss the results of the different groups. How did they think about and what choices did they make when they were to create quality? How did those who were to create quantity decide what choices to make? Discuss why we should buy good-quality clothes. What do we gain from that? Can we be sure that a good-quality garment is also good for the environment and for those who have worked in the manufacture of the garment?

Often, better quality costs a little more. Illustrate the relationship between price and quality through this calculation, which shows how much a garment costs per use.

- Winter jacket: 1000 kr/100 days of use each year for 2 years = 5 kr per use
- Party top: 50 kr/2 times = 25 kr per use. (SCAc, 2017, p. 7)

The *end-in-view* in this passage is to feel clever. This opens up a *gap* as to whether one is able to feel clever or not. The *relation* that emerges here is to buy clothes that will last, clothes that cost more, clothes that are good for the environment, and clothes that are good for people who have made the clothes and the clothes that one often wears. The *encounters* that can be identified in these relations are not only physical objects and entities, such as clothes, the environment and money, but also other people, for example, those who make the clothes. The encounters also point to ‘better quality’ (although it is not described in detail what that entails, but we can see that it costs more) and a habit of using clothes.

Other relations that emerge in this category with the end-in-view to feel clever can be divided into three different themes. The first theme is to have knowledge about clothes as consumption items, the second theme is to have knowledge about clothes’ fabric and the third theme is to have consumer’s knowledge and be able to take action based on that. In the table below all the relations identified are stated.

Table 2. Shows the findings from “feeling clever”.

To feel clever	Relations
Knowledge about clothes as consumptions items	not buy clothes based on impulse
	to have clothes that you actually need
	to think about what clothes you need
	to not to shop so much
	to not to buy wear-and-tear
Knowledge about clothes' fabric	to know that the garment will not break
	to have knowledge of the quality of the material
	to know how clothes are handled and mended
	to wash woollen garments by hand
	to have clothes that feels good on the body
Consumer's knowledge and actions	to not wash too often
	to save the receipt when buying
	to reward nice companies
	to send letters to responsible businesses and politicians
	to wear the same garment as a pursuit of sustainable fashion
	to buy clothes where the workers had good working conditions
	to write a debate article
	to find out more about labels so that the environment workers or consumers are not harmed

As one can see, there are many “clever” actions one can do, and they are all related to specific aesthetic judgements that point to different actions of feeling clever. As a conclusion, to feel clever is an end-in-view that promotes a certain meaning making about sustainable clothing consumption, which we now summarise with some concluding remarks.

Concluding remarks: aesthetics experiences and critical design literacy

The aim of this case study was to study the meaning making of sustainable clothing in an educational material named *Sustainable Fashion* produced for teachers in design and craft education. Based on the analysis, we can conclude that the educational material reveals a “taste” for the informed and capable pupil acting on clothing sustainability. Two ways of becoming a sustainable consumer of fashion have been identified – to have fun and to feel clever – and these meaning making activities incorporate certain actions of what it means to be a sustainable consumer. For example, there are certain ways of having fun in the educational material (see table 1) and there are certain ways of feeling clever (see table 2). What the result shows is that the meaning making produced in the educational material provide certain norms and certain ways to act. When students are taking part in these design projects, the meaning making of having fun and feeling clever will be presented to them and they will learn whether they “belong” in the activity and how. That is, if they agree (or not) on the meaning making of having fun and feel clever and act accordingly. As they do, they will also learn whether (or not) they can be recognised as sustainable consumers.

By making the meaning that is produced through the aesthetic experiences in the educational material visible, we can more easily discuss other possibilities. For example, what other ways making meaning with sustainable clothing are possible? As Fletcher (2015, p. 20) reminds us, noted above, there is a possibility to re-appreciate the potential of fashion to nourish and foster other actions, as we dress. By making the meaning explicit in the educational material, we can critically discuss its outcome and based on that, open up for other possibilities that is of relevance for critical design literacy. After all, we all wear clothes and thus learning critical design literacy is essential for a more sustainable future.

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Framing students' reflective interactions based on photos

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Critical reflection, addressing students' attitude, beliefs and values related to pressing topics in the world, plays a crucial role in developing ethical sensitiveness and critical design literacy in design education. Critical reflection is provoked by discussing self-made photos, as is demonstrated in the research method *Photovoice*. This paper considers Photovoice in design education for its ability to foster learning through *self-guided critical reflective interactions* with peers based on self-made photos. Research on how to support this is lacking. This paper addresses this gap by studying students engaging in self-guided Photovoice assignments. Results consist of adapted steps for Photovoice in education and illustrate potential as well as boundaries of self-guided Photovoice through students' quotes and *photomaps*. Also, five *frames of interpretation*, suggested by students engaged in self-guided Photovoice, contribute to previous knowledge and may inspire the design education community to start experimenting with Photovoice in course work. The final aim is to support students in critical reflection, a crucial skill for responsible design professionals.

Keywords: Photo sharing, Photovoice, Critical reflection, Interpretation, Learning

Introduction

In design education, the ability to reflect is crucial for students to become responsible design professionals and creative thinkers (Dewey, 1933; Kolb, 1984; Norman, 1993; Schön, 1983). More than *reflection* – which focuses on the improvements of actions in an established field of practice –, *critical reflection* – which addresses students' attitude, beliefs and values related to pressing topics in the world – is considered crucial in transforming knowledge and practice and in developing ethical sensitiveness and *critical* design literacy (Mezirow, 1997; Orr, 1991). At the same time, it can be hard for educators to turn reflection from an individual cognitive process inside student's head into a social, tangible and preferably self-guided process in class (Chio & Fandt, 2007; Fleck & Fitzpatrick, 2010). There is a need for methodologies and exercises supporting self-guided critical reflection in design education.

Research shows that taking photos and discussing them with others provokes reflection (Harper, 2002; Hurworth, 2003; Latz, 2017; Mendelson, 2007; Sontag, 1977; Tinkler, 2013). Photos have the visceral power to communicate not only what is shown in the photo: *the signifier*, but also what idea or meaning it refers to: *the signified* (Saussure, 1961). When transitioning from *describing the signifier* towards *interpreting the signified*, a process of reflection occurs, characterised by 'reviewing experiences' (Baumer et al., 2014) and 'coordinating one's beliefs, values and internal loyalties' (Baxter Magolda & King, 2012), supportive for ethical and cultural sensitiveness and critical design literacy (see Fig. 1).

The research method of *Photovoice* (Wang, 1999; Wang & Burris, 1994, 1997) builds on this power of photos. Historically, Photovoice has been used to highlight the perspectives or *voices* of often marginalised groups in society. Through dialogue about self-made photos, participants reflect on topics important to their daily lives and are empowered to make themselves heard. This paper focuses on the use of Photovoice in design education and considers its ability to foster *critical reflective interactions*. With this term the social, active and personal character of reflection built on interaction about and with self-made photos is emphasised.



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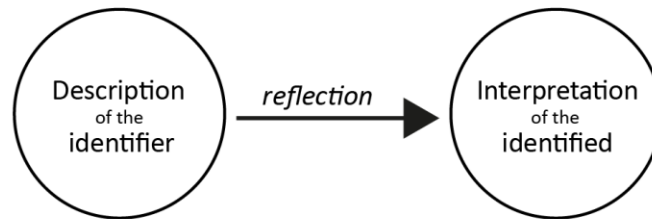


Figure 1: Reflection occurs when transitioning from describing the identifier towards interpreting the identified (based on semiotic theory of F. de Saussure (1961).

To support reflection in Photovoice, literature suggests the use of questions, caption writing and storytelling in a process controlled by the researcher (Wang, 1999; Wang & Burris, 1994, 1997). In the context of learning, better results are to be expected when students guide their own learning process (Mezirow, 1997). However, there seems to be a lack of knowledge and practical applications on how to achieve this in Photovoice. This paper aims to address this gap to be able to support students in self-guided, critical reflective interactions with peers based on self-made photos. However, first we need to better understand what happens when students engage in such a process.

An explorative user study with bachelor design students engaging in Photovoice assignments was performed. The results consist of 1) an adaptation of the steps of conventional Photovoice into steps suitable for use in education, 2) quotes and students' deliverables illustrating the potential and boundaries of Photovoice in education and 3) five *frames of interpretation* of self-made photos by students. With these results we aim to strengthen the design education community in its attempt to support self-guided critical reflective processes and help students to become responsible design professionals and creative thinkers.

Theory and related work

In this section we will introduce founding theories and related work.

Photovoice

Photovoice is a form of participatory action research (Lewin, 1946). It is closely associated with research of Wang and Burris, who coined the term 'Photovoice' in the 1990s (Wang & Burris, 1994). Traditionally, the method focuses on marginalised groups in society and proved to be a powerful means to (a) encourage documentation of their lives, (b) raise critical reflection through dialogue about their photos and (c) reach policy makers to catalyse change (Latz, 2017). As opposed to *Photo-elicitation* (Harper, 2002), Photovoice is participant driven, meaning that photos created by the participants themselves are in the heart of the process. Research describes typical steps to take in a Photovoice process (Latz, 2017; Tinkler, 2013; Wang, 1999):

- Step 1: Identification. The researcher identifies the concept(s) to be explored.
- Step 2: Invitation. The researcher invites the participants.
- Step 3: Education. The researcher informs the participants about the concepts and procedure.
- Step 4: Documentation. Participants take photos.
- Step 5: Narration. Participants, guided by the researcher, discuss and reflect on their self-made photos. A set of questions, raised by the researcher, may be used to support this step (Wang, 1999).
- Step 6: Ideation. The photos are analysed as a set. Connections between photos of participants are labelled – often by the researcher. Literature on Photovoice recognizes the importance of involving participants in this step for the learning and reflection that takes place (Sutton-Brown, 2014), however suggests that this is not always feasible. Literature on supporting this step is limited. General references are made to 'caption writing' and 'storytelling'.
- Step 7: Presentation. Participants and researcher co-create an exhibit for a wider audience.
- Step 8: Confirmation. The perception of those who visited the presentation, including policy makers.

Arguments against the use of Photovoice often refer to the potential risk of upsetting vulnerable participants when exploring sensitive concepts (Booth & Booth, 2003; Latz, 2017; Wang & Burris, 1997). When using Photovoice as a means to facilitate students' learning these arguments are less troublesome. Although some concepts might be sensitive to some students, it is never the aim to address specific problematic issues in the

lives of the students as a group – as is the goal of conventional Photovoice projects. The risk of upsetting students may therefore be small. A second argument against the use of Photovoice refers to potential difficulties to analyse the photos, due to their subjective nature. This will be discussed later.

Photovoice for critical, reflective learning

Paolo Freire's education for *critical consciousness* is one of the theoretical foundations of Photovoice. Freire's central premise is that education is not neutral and takes place in the context of students' lives (Freire & Ramos, 1970). Drawings made by Freire were used to stimulate collective reflection and discussion among students. A similar approach is used in Photovoice. Freire's drawings represent realities of daily life, the photos created with Photovoice do that as well. However, Photovoice takes the concept one step further by focusing on artefacts (photos) created by the students themselves.

As stated, conventional Photovoice is directed towards reaching policy makers. When Photovoice is used in education, the process is directed towards student reflection. Research on Photovoice in education has emphasised critical reflection on issues such as cultural diversity and gender inequality (Ali-Khan & Siry, 2014; Chio & Fandt, 2007; Kaplan & Howes, 2004), racism and sexism (Sensoy, 2011) or health (Cooper, Sorensen & Yarbrough, 2017). However, suggestions on how to support *self-guided* critical reflection are lacking.

Reflective learning assignments

We selected theories on Self-Authorship (Baxter Magolda & King, 2012) and Basic Human Values (Schwartz, 2012) to define concepts for the Photovoice-assignments. Self-Authorship is characterised by internally generating and coordinating one's beliefs, values and loyalties, rather than depending on external values (e.g., from parents), external beliefs and interpersonal loyalties. By definition, it is strongly related to critical reflection. The theory states that all learning outcomes require a certain level of Self-Authorship and move away from binary assessment of knowledge such as right or wrong. Knowledge assessment and critical reflection require more sophisticated treatments that involve ambiguity and often generate more questions than answers. Students should be supported in a self-guided process to 'actively work on developing internal perspectives and self-definition' and to become 'the Author of One's Own Life'.

To have students actively work on developing internal perspectives and self-definition, the Theory of Basic Human Values (Schwartz, 2012) served as inspiration for the definition of the concepts to explore with photos. It is stated that individuals and groups differ substantially in the importance they attribute to basic values such as 'self-transcendence' and 'conservation'. Researching these different priorities or hierarchies involves researching internal perspectives and self-definition, supporting Self-Authorship and critical reflection.

Analysing photos

Due to their subjective nature, photos are considered hard to analyse. However, when Photovoice is used in design education the analysing or interpretation of the photos is not done by the researcher but by the students as part of the reflection process. In this research, we aim to better understand this process and to *analyse the analysis of the students*, to be able to support it. Since a photo can be considered a sign, theories from semiotics, the study of signs, were consulted. Swiss linguist, semiotician and philosopher Saussure conceptualised a sign as a *referent* (Saussure, 1961). The referent refers to what is depicted in the photo: *the signifier*, as well as to the meaning of the thing in the photo: *the signified*. A sign consists of both: a totally meaningless signifier or a completely formless signified does not exist. However, the same signifier could refer to different signifieds. For example: a photo of a sleeping cat is both referring to 'a sleeping cat' (the signifier) and to 'my cat I love so much', 'relaxedness', 'flea infestation' etc (the signified). As such, the signified can include the thing in the photo but also refer to an abstract idea or concept.

Theories of the American logician, mathematician and philosopher Peirce also informed our analysis. Peirce defined three modes of relationships between signs and their referents: *the iconic*, *the indexical* and *the symbolic* (Peirce, 1960). Employed within a broadly Saussurean framework, the iconic relationship tends to emphasise the signifier, while indexical and symbolic relationships tend to emphasise the signified. In the iconic mode the signifier is perceived as resembling the signified, being similar in possessing some of its qualities. In the case of photos, there is always an iconic relationship, since photos are in a certain respect exactly like the object they represent. In the indexical mode the signifier is directly connected to the signified in a physical, observable way or in a causal, inferential way. The relationship is not arbitrary. For example: a photo of smoke refers to fire. In the symbolic mode the signifier does not resemble the signified but relates to it in a fundamentally arbitrary or conventional way. The relationship must be learnt, for example: a photo of a

white dove might refer to peace.

Research has been done on the practical use of icon, index and symbol in assigning meaning to and querying of photos (Nack, Scherp & Neuhaus, 2014). Findings suggest that this established division does not correspond with the actual reasoning and reflecting process of the participants. Specifically, the distinction between the indexical and symbolic meaning of photos could not be reproduced. It is suggested that a dyadic division between iconic and indexical/symbolic, resembling the identifier and the identified in Saussurean terms, should suffice. In this research this dyadic approach is the primary guiding principle for the analysis. See Fig. 1.

The study

To better understand the process of critical reflective interactions based on self-made photos we performed a user study with two cohorts of 3rd-year bachelor students participating in a minor program on design research at a University of Applied Sciences in the Netherlands. 31 students participated: 14 in 2019 and 17 in 2020 (see table 1). The main author of this paper took the role of educator in the program.

The assignments

A learning goal of the course was to develop a professional attitude as a design professional. In order to encourage students to 'actively work on developing internal perspectives and self-definition' (Baxter Magolda & King, 2012) as a means to fulfil this learning goal, we carefully defined three concepts inspired by the Theory of Basic Human Values (Schwartz, 2012):

- **Social city** – We envisioned this concept to contribute to the exploring of internal perspectives on what constitutes a social society. Inspired by the human value 'self-transcendence' (Schwartz, 2012).
- **Traditional city** – We envisioned this concept to contribute to the exploring of internal perspectives on what constitutes 'tradition'. Inspired by the human value 'conservation' (Schwartz, 2012).
- **I love my city** – We envisioned this concept to nudge students towards expressions of self-definition in terms of preferences and opinions.

We aimed to explore the same concepts with the 2020-cohort, however due to Covid-19 restrictions we could not ask students to go out to explore. We therefore adjusted the concepts to guide a process of creating photos closer to home: (a) **Social home**, (b) **Traditional home** and (c) **I love my home**. Since the conceptual core of the concepts is unchanged, we expected these concepts to be interpreted in a similar way as the year before.

To complete the assignment both student cohorts were asked to document and illustrate the answers to two questions: (1) 'What did the group find out about the concepts?' resulting in a group document and (2) 'How would you describe your own perspective on the concepts?' in an individual document. To answer these questions, students discussed the photos and created *photomaps*: labelled configurations of photos to illustrate their interpretations (see Fig. 2).

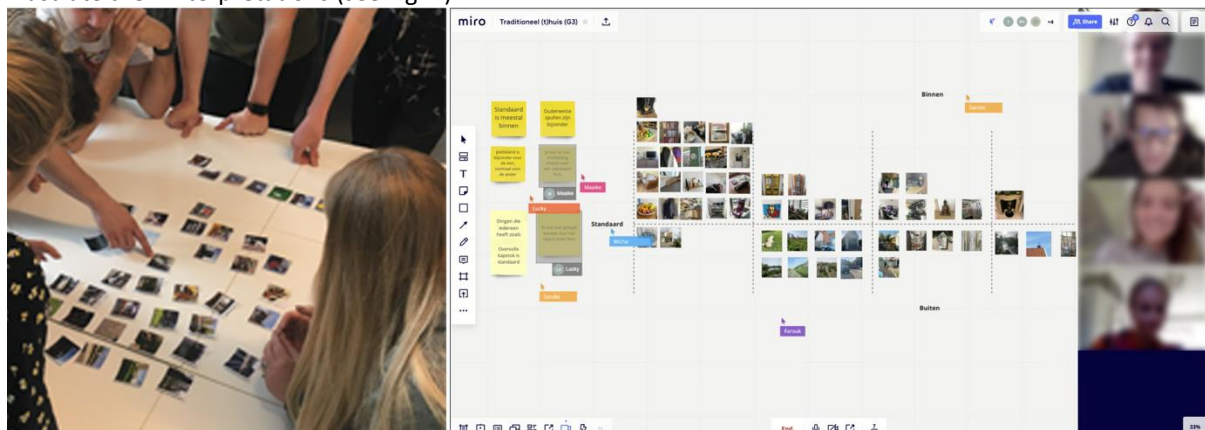


Figure 2: Students created photomaps through reflective interactions based on their self-made photos in class in 2019 (left) and in the online tool Miro (Miro, n.d.) in 2020 (right).

Data collection

The students were asked to create a minimum of nine photos per concept with their mobile phones. They

were given three days for this. In 2019, the photos were printed on paper by the educator shortly before discussing the photos in class. The students were divided into two subgroups. Each group was positioned at a table and provided with their photos as well as post-its and markers to support the reflective interactions. The students were informed that their activities would be recorded and asked for their consent.

Due to Covid-19 restrictions, the 2020-cohort could not meet up in class. Instead, they were asked to use an assigned board in the online white boarding tool Miro (Miro, n.d.) and engage in the video-chat (see Fig. 2). The Miro environment provides for digital post-its and markers. The group was divided into three subgroups. The students were informed that their activities on the board would be recorded and asked for their consent. Screen recordings including video and audio were made with video messaging tool Loom (Loom, n.d.). The students spent between 25 and 35 minutes per concept. They received little guidance on how to start their reflective interactions but were informed about what questions to answer to complete the assignment. In 2019, two educators were present during the discussing in class, however not interfering. In 2020, two educators were switching between the different allocated boards in the online environment and not interfering. The students were asked to deliver the documentation two days after the discussion session, as a pdf file.

Table 1: Set up of the study and overview of the collected data.

	2019	2020
Setting	Offline in class Printed photos	Online in Miro (Miro, n.d.) Digital photos
Support	Post-its Markers	Digital post-its Digital markers
Concepts to explore	Social city Traditional city I love my city	Social home Traditional home I love my home
Student population	14 (7 male, 7 female)	17 (10 male, 7 female)
Subgroups	Group 1: 7 students Group 2: 7 students	Group 1: 6 students Group 2: 5 students Group 3: 6 students
Data (discussions)	Video and audio recordings of 2 groups x 3 concepts = 6 recordings. Transcribed	Screen recordings (audio + video) of 3 groups x 3 concepts = 9 recordings. Transcribed
Data (documentation)	2 group documents 14 individual documents	3 group documents 17 individual documents

Data analysis

Unique codes were assigned to each student: P1-G1-19 means Participant 1 from subgroup 1 in 2019. The data were analysed using Thematic Analysis (Braun & Clarke, 2006). We took an inductive, data driven and bottom-up analytical approach (Boeije & Bleijenbergh, 2019; Langley, 1999; Miles & Huberman, 1994). This means that we did not try to fit a pre-existing coding schema but created one ourselves. However, knowledge on the division between *identifier* and *identified* (Saussure, 1961) was used as *sensitising concept* (Boeije & Bleijenbergh, 2019; Bowen, 2006) to recognize interpretations and distinguish them from descriptions.

We operated within a constructionist paradigm, meaning that we acknowledged that codes and themes were constructed by us and did not just speak for themselves (Boeije & Bleijenbergh, 2019; Braun & Clarke, 2006).

We were actively looking for pieces of narrative evidence which we selected, edited and applied to strengthen our arguments. As is good practice in a constructionist approach, excessive data reduction was avoided and the different viewpoints on the studied process were presented as completely as possible (Langley, 1999).

After the first period of familiarising ourselves with the data an iterative process was followed of open coding, constructing initial themes, reviewing them and defining final themes. Open coding means that as many codes as needed were assigned to pieces of text (Boeije & Bleijenbergh, 2019; Langley, 1999; Miles & Huberman, 1994), using the sensitising concepts as a lens. Spread sheet software was used to document the codes alongside the data extracts and photo (Figure 5). To determine if a code could constitute or be part of a theme, we again took a qualitative approach. The number of occurrences in the data was not the decisive measure, instead we looked for variety in codes. Since students might experience reflecting and interpreting as challenging (Fleck & Fitzpatrick, 2010), we took into account that successful efforts might occur only once, yet still be valuable for our analysis. After, but also during the process of open coding, mind-mapping techniques were used to merge, rename, split and finally cluster open codes and construct themes (Figure 6). The 15-point

checklist of criteria for good Thematic Analysis (Braun & Clarke, 2006) was consulted.

Results

Three types of results were gained: 1) an adaptation of the steps of conventional Photovoice into steps suitable for use of Photovoice in design education, 2) insights illustrating the potential and the boundaries of Photovoice in design education and 3) five *frames* of interpretation of self-made photos by students.

Adapted steps for Photovoice in design education

We propose adjustments in the process-steps of a conventional Photovoice-project to better facilitate critical reflection in an educational context. Figure 3 illustrates the shift in responsibilities for the actors involved.

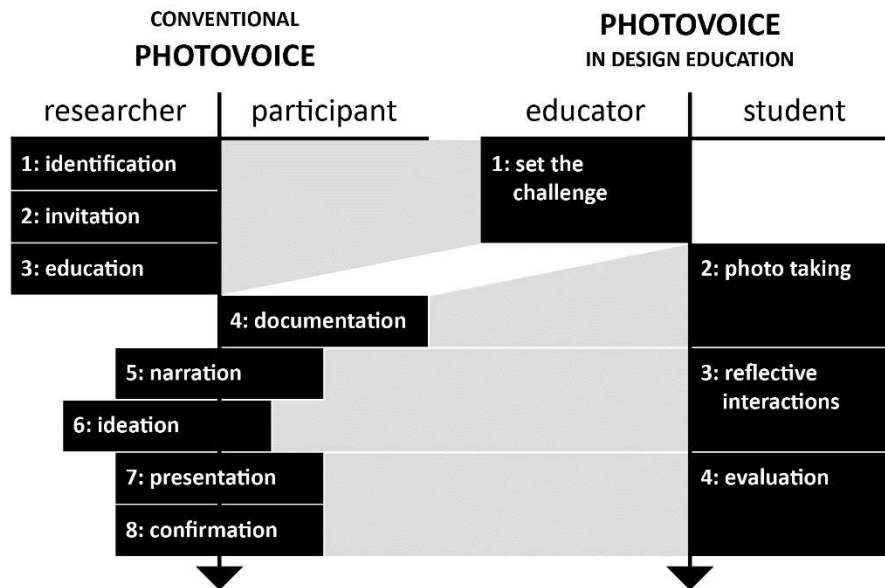


Figure 3: Adaptation of the steps in conventional Photovoice compared to Photovoice used in education.

- **Step 1: Set the challenge** – In this step the educator takes the leading role. It includes former steps 1: Identification, 2: Invitation and 3: Education. The concepts to explore should fit the learning goal of the course. They can be provided by the educator – as in this research –, by the students or co-created by both. Inviting students and informing them about the assignment is embedded in the course.
- **Step 2: Photo taking** – Students have the leading role in this step. It includes former step 4: Documentation. Students take photos with their mobile phones to explore a given concept.
- **Step 3: Reflective interactions** – Students take the leading role in this step, in which critical reflection and learning takes place through discussing of photos and the creation of photomaps. This step includes former steps 5: Narration and 6: Ideation. The educator may perform a facilitating role in the background.
- **Step 4: Evaluation** – Students take the leading role in this step. It includes former steps 7: Presentation and 8: Confirmation. Although the results from using Photovoice in design education might be of interest to others (for example other, not participating students), the aim of the process is critical reflection for the participating students themselves. Presenting the results to a wider audience of policy makers is not in focus. We therefore restrict this step to evaluation of the Photovoice results by the students, a reflective activity that may deepen the insights gained during the reflective interactions. The evaluation is often captured in a document, as in this research. However, other means of evaluation could be suggested, such as a presentation or an exhibition. The evaluation may be graded.

This research focused on step 3: Reflective interactions. Previous research suggests that a) reflection can be challenging (Fleck & Fitzpatrick, 2010) and b) sharing and discussing photos support reflection (Harper, 2002; Hurworth, 2003; Latz, 2017; Tinkler, 2013). In this research evidence supporting both claims was found. First of all, we observed that reflection can be challenging: transforming from describing the identifier towards interpreting the identified was not always easy or self-evident. Regardless of which concept was discussed first, all five groups in 2019 and 2020 started out describing the identifier or 'thing' in their photos and created categories of 'similar things'. It was not until the second or third concept that references to other interpretations were discussed and more complex connections between photos were recognized. Student P1-G1-20 stated: "I thought it was a shame that we as a group got stuck on just categorising photos for 'I love my home', because it had actually interested me enormously what kind of stories came with the photos." At the same time, students indicated that ultimately, sharing and discussing photos helped them to reflect: "If you just start talking about a particular topic, you will never get conversations or discussions as deep as you get with photos" (P5-G2-19) or "Behind all these photos is a story and if you bring them together you can form an image of the person behind them" (P2-G3-20). An example of students experiencing photos as means to develop internal perspectives and cultural sensitiveness that might not have surfaced without the use of photos is given by P5-G2-20: "Often I don't mention my background because I don't think it is necessary to talk about it, but with these photos it comes out in an interesting way". Moreover, some students mentioned specifically that photos may support self-definition or self-reflection. P5-G2-19 wrote: "This is not about pushing through your own opinion, but rather being open to other opinions". P4-G1-19: "I was forced to look beyond my own personal interpretations [...] and had no problem deepening my perspective". An example of a photomap of the concept 'Social city' illustrates how reflection took place (Fig. 4). After forming categories, students increased complexity by creating an axis in which the contraposition of 'antisocial' was introduced. Some photos, such as a photo of cigarette butts on the sidewalk, were perceived as ambiguous: was the photo referring to the leftovers of a social gathering or to littering and indifference? This triggered a more fundamental discussion about internal perspectives and attitude towards what constitutes 'social' and resulted in discussing the opposite as 'antisocial'. Also, the group concluded that "Social behaviour does not always have to be self-evident, so instructions or reminders in the city are needed", referring to the photos labelled with 'Affordance'. It suggests that 'beliefs, values and internal loyalties are being generated and coordinated', which could have a positive impact on students' development toward Self-Authorship and critical reflection (Baxter Magolda & King, 2012).

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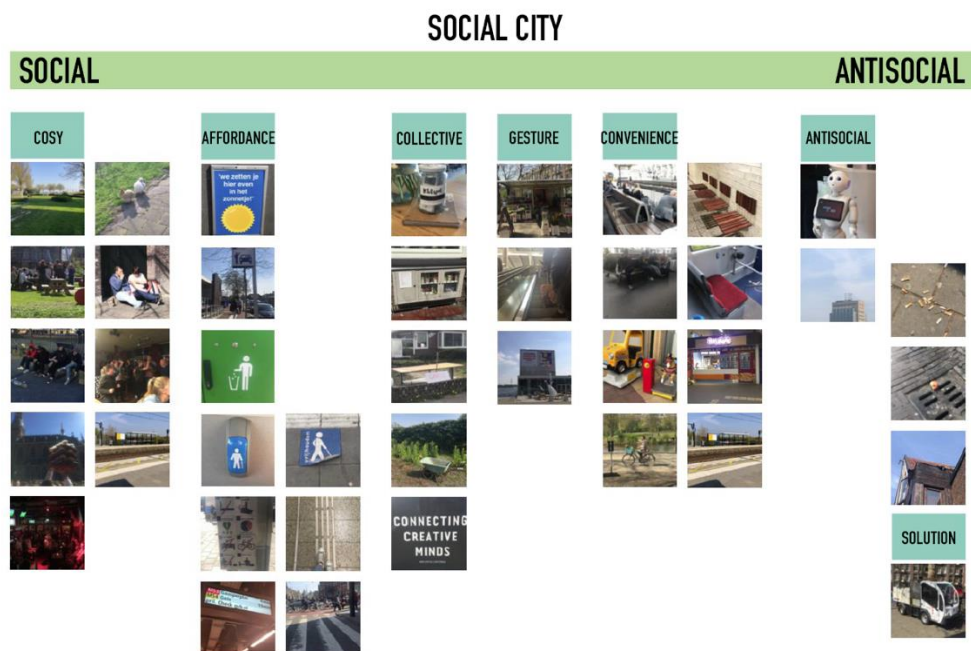


Figure 4: Photomap on the concept 'Social city' by G2-19. It is a digital reproduction, made by the students, of the photomap laid out on the table in class. The labels were translated from Dutch into English in the digital file, by the author.

Despite the potential of Photovoice for critical reflection in design education, we also witnessed students struggling with it. Frequently, they were stuck at the level of defining how the concept is interpreted according to the majority of the group without further explanation or deeper reflection. For example: G1-19 wrote on the concept 'I love my city': "Travelling is an important theme, as well as clean", without further explanation or critical reflection on what these themes may induce. P1-G3-20 wrote: "When I look at my photos of 'Social home' I see many objects that have to do with physical social activities instead of digital social activities", also without deeper reflection. P2-G1-19 judged the process of interpretation as complicated all together: "Can't we go back to categories, that is a lot easier."

We conclude that critical reflection can be challenging, although students recognize the potential of photos as triggers for critical reflection and achieved it occasionally. Students are able to express interpretations, however support is needed to explicate how these interpretations relate to 'beliefs, values and internal loyalties' or how they can be 'put together to create some sort of insight' (Baumer et al., 2014). The final result, discussed next, aims to contribute theory and practice for such support.

Photo	Data extract	Open code	Photo	Data extract	Open code
	My cupboards, and I have, you know, all my pens organised on Sharpies, Stabilos, black pens, blue pens... I just love that very much, that it is all organised. (P3-G2-20)	identity, personality trait, values, appearance		I don't like too much rubbish laying around. In my opinion, an organised set of boxes or bottles also illustrates a certain kind of affection and love for your home. (P5-G1-20)	identity, personality trait, opinion, values
	There are a lot of people in my neighbourhood with a kind of bookcase next to their house, from which you can take books or leave books behind. Is about to sharing things, doing things together. (P1-G2-19)	interaction, human, behaviour, sharing		I think I am good at logical thinking. The interpretation of the assignment shows that I have thought logically and literally about the word 'traditional' and based my photos on that. (P3-G1-20)	identity, personality trait
	This is very bright sky so that means prosperity... (P2-G1-19, photo by P6-G1-19)	symbol		I've made my house my home. I like the colours blue and green combined with wood. That is reflected in the photos. (P5-G3-20)	identity, preferences style
	In Scheveningen... we are known to be a bit dirty... of course a joke... that you have Tokkie* sauce. (P1-G1-19)	local symbol		I think the fact that we have to make room for each other and think about each other is social. You don't have to see each other physically to be social. (P6-G1-20)	the other, interaction, human, behaviour
	* Term to describe socially weak citizens I am of Pakistani descent, so I made photos of religious prayers and from the Quran. And also the dough we use to make food. (P5-G1-20)	culture, religion, roots		So we found out that social behavior does not always have to be self-evident and that incentives are therefore needed in the city. (G2-19)	interaction, behaviour, human, respect
	Sending birthday cards... that in itself is of course also a tradition, which almost everyone does. (P3-G1-20, photo by P1-G1-20)	culture, rituals, human, behaviour		The items in the photos refer to the past and what was the norm then and now no longer. (P6-G1-20, photo by P1-G1-20)	temporality, past, old reality, tradition

Figure 5: Assigning open codes to data from students' discussions (left) and documentation (right).

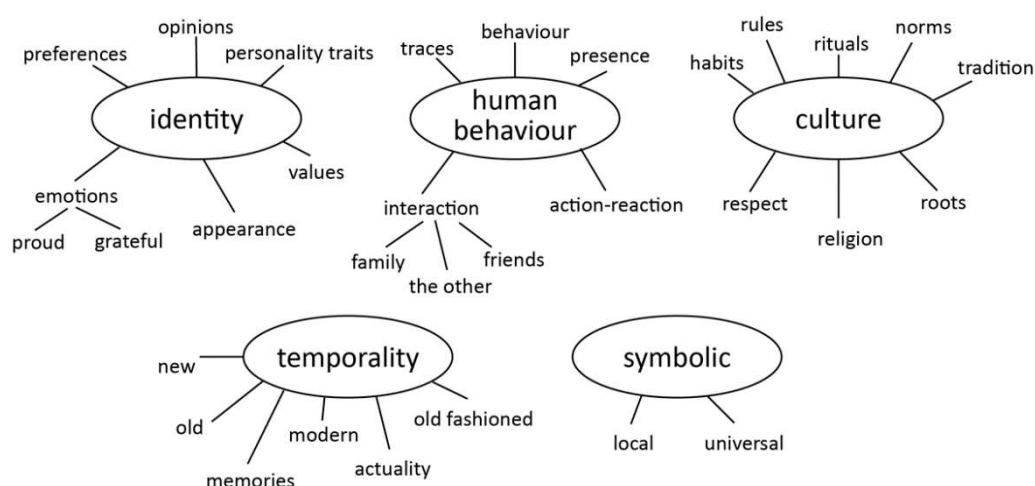


Figure 6: From the open codes, themes or frames were constructed.

The interpretation framework

Using Thematic Analysis (Braun & Clarke, 2006) the data were analysed for clues marking the transition from describing the content of a photo towards interpreting its meaning (Fig. 1). After an iterative process of open

coding (Fig. 5) and mind-mapping techniques, final themes were constructed (Fig. 6). These final themes represent *frames*, or *hypotheses about the connections among (parts of) photos* (Klein, Moon & Hoffman, 2006):

1. **Identity** – referring to the self
2. **Human behaviour** – referring to (interaction with) the other
3. **Culture** – referring to a wider context of influence
4. **Temporality** – related to (the passing of) time
5. **Symbolic** – referring to symbolic meaning

We took time to construct five ‘coherent, consistent and distinctive’ frames: point 6 of the 15-point checklist of criteria for good Thematic Analysis (Braun & Clarke, 2006). Three frames focus on *the human* but differ in their context of influence: *identity* (intrapersonal, smallest context of influence), *human behaviour* (interpersonal) and *culture* (widest context of influence based on established behaviour in larger groups). These three frames are essentially different from the fourth frame *temporality*, related to (the passing of) time and the fifth, referring to *symbolic* meaning.

Although the five frames are recognizable and distinct, we acknowledged that one single interpretation might be scaffolded by more than one frame. For example: the data of P3-G1-20 (fig. 6, left, final line) refer to *culture* as well as to *human behaviour*. Also, references to ‘memories’, positioned in the frame *temporality*, relate to and may overlap with ‘emotions’: part of the frame *identity*. This is in line with semiotic theories indicating that the same signifier could refer to different signifieds. Ultimately, depending on student and context, the focus is specified. In figure 7 the process of moving from describing towards interpreting a photo, illustrated in figure 1, is extended with the five frames into a framework. The boundaries between the frames are permeable to express flexible and combined use.

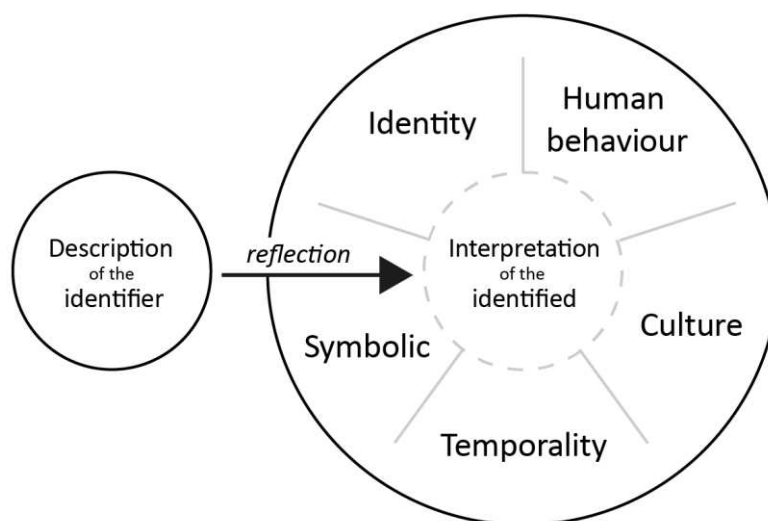


Figure 7: The interpretation framework consists of five frames suggested by students transitioning from describing towards interpreting their self-made photos.

The frame ‘symbolic’

Rarely, students refer to a symbol the way semioticians understand it: as a convention-based sign referring to an abstract concept. The occurrences in the data are illustrated in figure 5: a bright sky as symbol for prosperity and a bottle of ‘Tökkie sauce’ as symbol for a locally understood nickname of ‘somewhat messy’ people. However, often the word ‘symbol’ was used in a way that differs from the conventional, semiotic way. Instead, what is depicted in the photo is seen as a *symbol* for a personal, unique interpretation and is *symbolising* a related memory, habit, activity or preference. The relationship is direct and not based on conventions, thus indexical. An example is made by G1-20, stating that frames with family pictures and mottos presented in the home are ‘memories of relationships between people in a symbolic way’ (Figure 8). We conclude that the conceptual distinction between a photo as index or as symbol is rarely made by students.

This confirms earlier research (Nack et al., 2014).

Regardless the often alternative use of the term ‘symbol’, we incorporated the frame symbolic in our results. Doing so, the references made by the students are justified. Also, bringing students attention to this frame may help to discuss conventional (semiotic) symbolic qualities of their self-made photos, reveal more complex connections and support students in critical reflection.

Photo	Data extract	Open code	Theme
	These are memories of relationships of people in a symbolic way. The texts and the image represent something. [...] Often there is a reason why they are created or bought. (Documentation of G1-20. The students created a category ‘Symbolic’, containing these three photos.)	symbol, memory, past	Symbolic

Figure 8: Example of an alternative use of the word ‘symbolic’: referring to personal memory, habit, activity or preference.

Discussion

With this research an understanding of the process of critical reflective interactions based on self-made photos in design education was achieved. The results confirm the potential of Photovoice for critical reflection among students as stated in previous research and contribute detailed knowledge for practical and theoretical use. The first result builds on knowledge of conventional Photovoice (Latz, 2017; Tinkler, 2013; Wang, 1999) and contributes with adapted steps for Photovoice in education. A crucial difference with the conventional steps is that responsibilities shift from the educator to the students, potentially beneficial to self-guided learning (Mezirow, 1997). The adapted steps could contribute to theoretical knowledge on Photovoice in education and may encourage the design education community to start experimenting with Photovoice in course work. Other results underpin and illustrate the potential of Photovoice in design education through quotes and photomaps of students. However, it is also indicated where reflection stagnated and learning results were lagging. These findings may contribute to theoretical knowledge on Photovoice in education and strengthen the design education community to focus their attention on Photovoice to support critical reflection. The final result: the interpretation framework with five frames of interpreting self-made photos, may have theoretical as well as practical implications. We envision the frames to contribute to semiotic theories on signs (photos) as a means for critical reflection. The frames add a subdivision to the broader concept of *the identified* by Saussure (1961). To our knowledge, this has not been done before. Future research could investigate the applicability of the frames in other learning contexts, for example outside the design domain or with students of different age groups or cultural background, and enrich the frames. Also, the framework may provide a feasible schema for research purposes to code reflective interactions based on photos, taking into account that the frames could overlap.

On a practical level, the framework aims to inspire the design education community to start experimenting with self-guided Photovoice in course work. The frames could be translated into a set of *frame cards* to be used by students as reflective triggers in Photovoice assignments. The proposition would be that the frame cards nudge students – offline and online – towards diverse and deep interpretations. Future research could experiment with strategies and designs of the frame cards in course work, resulting in improvements of the framework. Another practical approach may involve video or audio, as a means to start critical reflection, resulting in expanding of the framework. We invite design educators and researchers to pick up this challenge.

Limitations

The data analysis has been performed by the first author of this paper only. This might be limiting the validity of the results, since a second coder may assign different codes leading to different frames. However, the open codes and frames were discussed in depth with other researchers and educators. We argue that this tempers the limiting effect of the one-coder approach.

Also, a fundamental characteristic of Thematic Analysis may have influenced the results, and that is the constructed character of the results. If we acknowledge the idea of the ‘researcher as an instrument’ (Wa-Mbaleka, 2020), we have to embrace subjectivity and “identify and monitor [our biases ...], to make clear how they may be shaping the collection and interpretation of data” (Merriam & Tisdell, 2015). In our case, it might have influenced the value of the results in terms of positioning. Since the aim was to inform designs and strategies to be used in design education, a designer-bias or educator-bias may have occurred (Graebner, Martin & Roundy, 2012). This could mean for example a purposeful aim for three until seven frames, not less and not more, because this fits the practical context of (designing for) the educational context.

Finally, in the analysis we did not account for the different settings in which the student cohorts operated: off-line in 2019 and online in 2020. However, we argue that our results are little affected by this. Crucial for valid conclusions was to create a comparable challenge for the two cohorts in terms of content and deliverables. We aimed to do so by placing the research in the same course with the same learning goals, by exploring the same concepts (naming differences between 2019 and 2020 did not affect the essence of the concepts) and by asking for the same deliverables. Other parameters, such as the amount of time given to take photos, to discuss them and to deliver the documentation are kept the same, however we might argue that varying these parameters would neither affect our findings. Our focus was to understand and find patterns in the interpretations of self-made photos by students and not (yet) to discover what conditions work best.

Conclusion

With this research we gained theoretical and practical knowledge on self-guided Photovoice in an educational context. Through a study with two student cohorts, we were able to suggest a) an adaptation of the steps in a conventional Photovoice setting into steps suitable for educational context, b) quotes and photomaps of students underpinning and illustrating the potential as well as the boundaries of Photovoice in education and c) an interpretation framework with five *frames* used by students to ‘hypothesise about the connections among data’ (Klein et al., 2006) in their shared self-made photos. With these results we aim to strengthen the design education community to start experimenting with self-guided Photovoice in course work. Observing the world, taking photos and discussing them with peers helps students to coordinate their beliefs, values and loyalties and supports ethical sensitiveness and critical design literacy. Ultimately, such critical reflective processes are crucial for students to grow and to develop into responsible, creative design professionals.

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Critical design literacy through reflection in design

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This paper discusses a conceptual review of three frameworks for students' reflection in general design education. The frameworks were selected for their different focus of attention with respect to students' engagement with design products and environmental impacts. The review results indicated that the focus of attention affected the topics of reflection: the how-topics related to product design, the why-topics related to environmental impacts and the what-topics related to multiple solutions to challenges in both product design and environments. The paper discusses how researchers, teachers and students have different perspectives on whether the topics of reflection operate within established fields of practice or aim to transform them. The frameworks for reflection provide different contributions to enhance students' critical design literacy.

Keywords: critical design literacy; reflection; general design education

Critical design literacy

Critical design literacy is considered a key design competence for the development of sustainable societies and a potential learning outcome of design education. This competence encompasses aspects of both practice and reflection in design, and challenges design education to support students' development of their capacity to question, rethink and transform design practice.

The concept of critical design literacy draws on imbricated concepts and fields of research. *Design* relates to the making and understanding of products and systems (Nielsen, 2008a, p. 25), with the intended 'courses of action aimed at changing existing situations into preferred ones' (Simon, 1996, p. 111). *Literacy* refers to a competence for understanding and using knowledge in context (Ongstad, 2014; United Nations Educational, Scientific and Cultural Organization [UNESCO] 2004, 2005b). *Design literacy* is described as a competence to understand and create design of products in physical materials in a context supporting the development of sustainable environments (Nielsen & Brænne, 2013). This competence is also referred to as *design literacy for sustainability* (Maus, 2019a, 2019b, 2020), in reference to the aims of developing sustainability in ecological, social and economic environments across generations (World Commission on Environment and Development [WCED], 1987). Also, closely related and embedded in design literacy is research on the use of ecological literacy in design, concerning ecological systems and how products and production process interfere with these (Boehnert, 2015; Lutnæs & Fallingén, 2017; Stegall, 2006). The *critical* aspect of design literacy is described in research on *critical innovation* (Lutnæs, 2019), and in associated research on the potential to enhance critical thinking and creativity for the development of sustainable societies (Lutnæs, 2015a, 2015b, 2017). Related research encompasses students' stances towards inquiry (Christensen, Hjorth, Iversen & Blikstein, 2016; Christensen, Hjorth, Iversen & Smith, 2018).

Critical design literacy is described as a competence for change in attitudes and actions, which empowers students to question established fields of practices. Aspects argued to be of importance to students' development of this competence are a reflection of challenges to be solved in the world *outside* the school studio, rather than only as a reflection on challenges to be solved in the process of making a product (Lutnæs, 2020). Moreover, critical reflection is performed on the *why* of action with the aim of transforming current knowledge and cultural practices rather than only on the *how* of action within an established field of practice (Lutnæs, 2021). This interpretation of the distinction between the roles of reflection on how and critical



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reflection on why in learning process is based on Mezirows's (1990) description of the fostering of critical reflection in adulthood. However, students develop their design literacy gradually through all levels of design education (European Design Leadership Board, 2012, pp. 67–71), and design literacy research encompasses general education (Nielsen & Digranes, 2012), professional design education (Pacione, 2010) and industrial design education (Clune, 2007). An application of this interpretation of critical reflection from adult education to educational practice for youth will require an examination of how topics of reflection can challenge perspectives on established practice among participants at a general level of education. The researchers, teachers and students will consider different practices as established, and therefore have different perspectives for their questioning of why and how they are used.

This paper consists of an inquiry into three frameworks for reflection in design education, which have different approaches to encouraging students to question, rethink and transform current design practice. The aim of this study is to show how the focus of attention on design products and environmental impacts can affect the how and why of action. Moreover, to discuss perspectives on how these frameworks support students to both operate within established fields of practices and to transform them. Thus, to discuss these frameworks' potentials for supporting students' development of their own critical design literacy.

Method of inquiry: A conceptual review of topics of reflection frameworks

The research presented in this paper was conducted through a conceptual review and analysis of the topics concerning the why and how of actions in design, which were embedded in three frameworks for students' reflections in general design education (Hofverberg & Maivorsdotter, 2018; Maus, 2019b; Lutnæs, 2017). The aim was to analyse how the topics of reflection about why and how in design practice are affected by the area of focus concerning the influence between students, design products and environmental impacts.

Furthermore, to discuss how the students, teachers and researchers have different perspectives about whether these topics operate within established fields of practice or aim to transform them. The study draws on, and is a further development of, the research presented in my article-based PhD thesis (Maus, 2020). The review design was inspired by Maxwell's (2006) description of literature reviews for research with relevance, creation of focus, conceptual framework, design and justification for the research, rather than reviews of a field of research. This can entail relevant theories, findings and methods from other fields or disciplines. In this study, I analyse and discuss frameworks located through review of research conducted with different intentions and methods.

The publications with reflection frameworks were selected from a literature and document review of environmental sustainability as a topic in the general crafts and design education in the Norwegian school subject Art and Crafts. Included in the review were also a few highly relevant publications from other areas of design education and from other countries. The review was conducted through searches in journals (i.e. *FormAkademisk – Research Journal for Design and Design Education*, *Techne Series – Research in Sloyd Education and Craft Science A*, *Nordic Journal of Art and Research and Studies in Material Thinking*), database engines (i.e. *Education Resources Information Center [ERIC]* and *Open Digital Archive [ODA]*) and conference proceedings (e.g. *The International Conference on Engineering and Product Design Education [E&PDE]*). The review was concluded in 2020.

The publications located were organised according to their focus and methods' emphasis on the ideological, formal, perceived, operationalized and experiential levels in curriculum inquiry (Goodlad, Klein & Tye, 1979). In these, frameworks for students' reflection were found in publications based on perceived interpretations in research (Lutnæs, 2015b, 2017), operationalized educational practice (Bråten & Kvalbein, 2014) and experiential learning among students (Hofverberg & Maivorsdotter, 2018; Maus, 2019a, 2019b).

The frameworks for students' reflection were analysed according to the Model of educational practice in design for sustainability (DfS) to locate their focuses regarding the influence between students, design products and environmental impacts, and some of these (Bråten & Kvalbein, 2014; Lutnæs, 2017; Maus, 2019a, 2019b) were discussed in my PhD thesis (Maus, 2020). In the research for these papers on topics of reflection about why and how in design, the scope concerned three publications written in English (Hofverberg & Maivorsdotter, 2018; Maus, 2019b; Lutnæs, 2017), which made them accessible to a larger group of readers. The different areas of focus are visualised in a variation of the Model of educational practice in DfS (Figure 1).

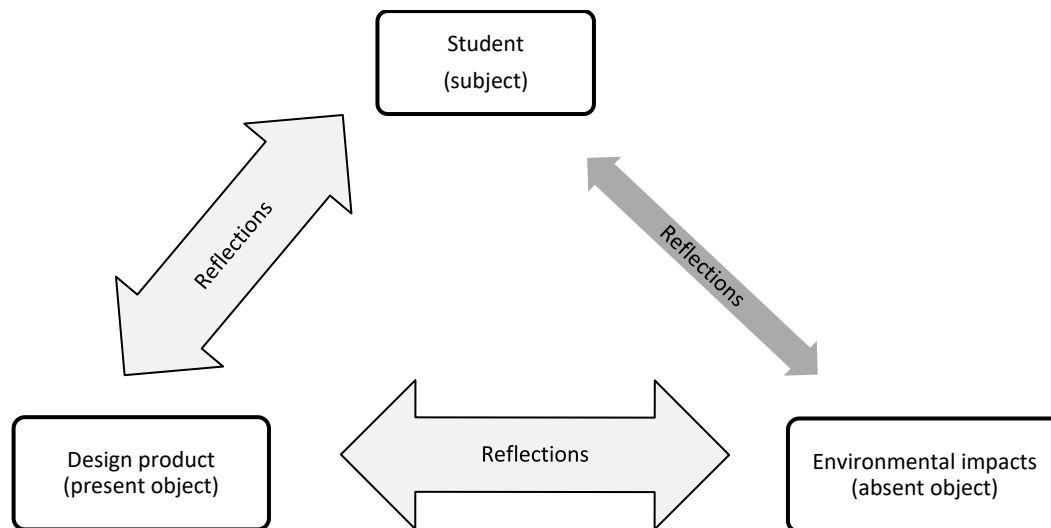


Figure 1: This model is a variation of the Model of educational practice in design for sustainability (Maus, 2017, 2019a, 2019b, 2020). The model structures a selection of frameworks for students' reflections according to their focus of attention on the following relations: (1) student–design product (Hofverberg & Maivorsdotter, 2018), (2) design product–environmental impacts (Maus, 2019b) or (3) student–environmental impacts (Lutnæs, 2017).

This model outlines students' engagement with the influences between the student (the subject), his or her design product (present object), which is present in the school studio, and the products' potential environmental impacts (absent object) which are absent from the school. The structuring of the three selected frameworks for students' reflection displays their different focus with respect to reflections about the why and how of actions in design. These involve focus on:

- Student–design product relationships through transacting with product ideas, materials' capabilities and remake techniques: This research is situated in a remake project with used-garments in the craft subject educational sloyd in Sweden in 2015, in which 15 students in the eighth grade participated. The data consisted of 20 hours of video recordings (Hofverberg & Maivorsdotter, 2018). The paper presented an analysis of the students' learning process and dialogs with their teacher. This research method focused on students' experiential learning during the operationalized educational practice.
- Design product–environmental impacts through introductions and tasks during practice and product assessment in craft-based design for sustainability (DfS): This research was situated in a woodworking project an art and crafts class in Norway in 2015-2016, where two teachers and 26 eighth-grade students (aged 12–13) in two groups participated. The data, constructed through action research, consisted of video recording transcripts with timekeeping and observation notes from one group (18 lessons, 27 hr total) and students' project books with tasks and self-evaluation responses (N = 24; Maus, 2019b). Hence, this research method focused on the on the students' experiential learning during and after the operationalized educational practice.
- Student–environmental impacts through confrontation, exploration, evaluation and transformation of consumption culture: This research was conducted through analysis and discussion of key texts on reflective inquiry (Dewey, 1933 [1910]; Schön, 1983; Freire, 1970) and methods from systems- oriented design (Lutnæs, 2017). This research method focused on researchers perceived interpretations presented in research.

The structuring of these three frameworks for reflection shows how the frameworks complement each other by focusing on the different areas, and thereby contribute to the development of different aspects of students' critical design literacy.

The topics of reflection on action in the articles were derived from a thematic analysis (King & Horrocks, 2010) with: (1) descriptive coding done by highlighting and extracting the frameworks for reflection and relevant reflection descriptions; (2) interpretive coding of the topics of reflections on the why, how and what of action in the frameworks and reflection descriptions; (3) defining overarching themes that describe the pattern of how the focus of attention affect the topics of reflection.

Reflection practices

The three selected frameworks for promoting students' reflection in design education have their similarities, but also their differences in aims, focuses of attention, steps and topics of reflection. An analysis of these frameworks show that their focus of attention affected the topics of reflection about how and why in action. Moreover, how researchers, teachers and students have different perspectives on whether the topics of reflection operate within or aim to transform established fields of practice.

Remake project with transacting relations

The students' engagement with the crafting of a design product with reuse materials is in focus in the work by Hofverberg and Maivorsdotter (2018), where they examine the students' learning processes in a remake project. Their analysis of students' learning processes consists of the purposes of the events in the remake process and the gaps the students must fill to achieve these purpose. Moreover, the relations they use to fill these gaps, including their aesthetic judgements of experience that move towards or away from fulfilment of the purpose, and finally the encounter between the students, their teacher, their peers and the physical world. The three-step framework derived from the result of this analysis encompass three categories of students' transacting relations:

1. Transacting with the idea of a product. The reflection topics in this step concern what kind of product to make from the reuse materials.
2. Transacting with a material's capabilities. The reflection topics in this step concern what is a doable use of the reuse material.
3. Transacting with remake techniques. The reflection topics in this step concern what is an appropriate technique for making the new product.

Questioning the fields of remake practice

The different perspectives on the remake practices guide interpretations of whether reflections about what kind of product to make, what is a doable reuse of materials and what is an appropriate technique for the students remaking of one object into something new operates within or aim to transform established fields of remake practice.

The researchers in this project asked questions about why students should learn to practice remake techniques. The researchers studied the learning outcomes of reuse projects and how they contributed to environmental and sustainability education (ESE), as they noted that research generally only assumes that remake leads to ESE learning outcomes. Hofverberg and Maivorsdotter (2018) emphasised ESE concerns related to human-material relationships and calls for cautions and contra-action in the remake projects. Their research results indicated that the students' ideas and bodies, as well as the used material and the teachers' knowledge, were transactants in the transactions during the students' learning process. The students' reflections were based on both positive and negative aesthetic experiences of how the product, materials and techniques could serve the intended function of the product (Hofverberg & Maivorsdotter, 2018).

The teacher carried out the remake projects of this study in 8th grade in the Swedish craft subject educational sloyd. Throughout the educational practice, the teacher expressed knowledge and cultural practice on ideas of the products, the materials' capabilities and remake techniques. The teacher asked the students' questions, informed them and guided them on choices in the design, including the selections of materials, the ideation of the products to make and crafts techniques to employ in the remake process (Hofverberg & Maivorsdotter, 2018).

The students' field of remake practice was developed and established through their own practice together with their fellow students in the school studio. The students started out with their reuse materials and used garments, from which they were to ideate and design new products. During the process of designing, the students were transacting with the idea of the product, the materials' capabilities and the remake techniques. When the students ran into challenging situations, either they asked their teacher for assistance or the teacher approached to support them. The students' reflected upon the teachers' responses, questions, information and instructions and discussed these with the teacher and each other. The questions concerned the topics of what kind of product to make, what the remake materials' qualities are, what kind of new products these material qualities were suitable for and what a suitable technique for the making of the new product was (Hofverberg & Maivorsdotter, 2018). These topics of reflection between the students and the teacher focused on the what of actions rather than the why or how. There was an agreement that they were to practice remake, but not about how to practice that remake. Instead, the questions of what to practice in remake took a position between the why and how by indicating that there could be more than one possible solution on

what materials to choose, what product to make and what techniques to use. Through the project, the students developed and transformed their own knowledge and skills concerning qualities in products, materials and techniques which are needed to rethink and transform unsustainable practices of waste disposal into practices of material reuse.

Introductions and tasks in craft-based design for sustainability

The students' engagement with the influences between their design products and the products' environmental impacts were the focus in the work by Maus (2019b), which investigated the embedding of design for sustainability (DfS) in the students' creation of a craft-based design product. The two-step framework to enhance students' reflection encompasses:

1. Practice in craft-based DfS, with introductions and tightly structured tasks based on examples of DfS principles and practices during decision-making situations about the design in sketches, work drawings and material selection when making a product. The topics in this step concern why practices for product durability and efficient, circular use of resources are environmentally considerate and what the students' use of these practices in their product consist of.
2. Product assessment after craft-based DfS, with introductions and tightly structured tasks on examples of DfS principles and practices in a project book. The topics in this step concern why practices for product durability and efficient, circular use of resources are environmentally considerate and the students' use of these practices in their product.

Questioning the fields of craft-based design for sustainability practice

The different perspectives on craft-based DfS practices guide interpretations of whether reflections about why practices for product durability and efficient, circular use of resources are environmentally considerate and the students' use of these practice in their product, operate within or aim to transform established fields of craft-based DfS practice.

The researcher in this project asked questions about why students should learn to practice DfS in craft-based design and how this can contribute to education for sustainable development (UNESCO, 2005a). Maus (2019b) selected a theory of task sequencing to support students' learning (Edwards, 2015) and theories of DfS principles and practices, and employed these in the development of the framework for students' reflections on environmental concerns in their craft-based product design. The DfS principles were life cycle thinking (LCT) about products' life cycles with their environmental impacts due to raw-materials extraction, manufacturing, distribution, use and disposal (Heiskanen, 2002) and the triple bottom line (TBL) aims for sustainability with environmental quality, social equality and economic prosperity (Elkington, 1999). The DfS practices were design for eco-efficiency, with low cradle-to-grave use of resources (Cooper, 2005, 2010), and eco-effectiveness, with the circular use of resources from cradle to cradle (McDonough & Braungart, 2009, 2013). Moreover, design for product durability and longevity through intrinsic product qualities, outer aesthetic product qualities (Cooper, 2005, 2010), functional product qualities (Stahel, 2010) and emotionally durable products (Chapman, 2009, 2010, 2015). The use of task sequencing and DfS theories aimed at enhancing learning established ideas about how to practice environmentally considerate design, but the use of these in craft-based design transformed and expanded these ideas.

The teachers collaborated with the researcher in this action-research project in eighth grade in the Norwegian school subject Art and Crafts. Together, they developed introductions and tightly structured task in seven interpretive themes, which established and exemplified the DfS practices in the students' craft-based design processes and the product. The themes were design and sustainability; functional design; accuracy in craft; materials with sustainable life cycle; construction, repair and maintenance; and value, price, wages and material costs. The introductions and tasks related to current knowledge and cultural practice in the field craft-based design education, and embedded DfS methods for environmentally considerate design in these (Maus, 2019b).

The students participated in the development of the field of craft-based design practice in general education to include DfS. They engaged in the introductions and tasks during decision-making situations about the design in sketches, work drawings and material selection when making their product, as well as during the product assessment after making the product. The introductions and tasks concerned why the practices for product durability and efficient, circular use of resources are environmentally considerate and what their use of these practices in their design product were. Through the project, the students developed knowledge and skills about ways to practice DfS, including reflecting on the product materials' life cycle and developing solutions for intrinsic, aesthetic, functional and emotional product qualities. Though this, they learned general design

methods for questioning products' potential environmental impacts and products' environmental information, which they can use on both self-made and professional products. Thus, the students developed competences to practice within established fields of practice, as well as to question and transform them.

Reflective inquiry on consumption culture

The students' engagement with the environmental impacts of their consumption were the focus of the work by Lutnæs (2017). The framework structured a reflective inquiry for students to rethink consumption culture, with the aim of enhancing the skills to rethink and transform patterns of unsustainable practices in the consumption of products. This four-step framework consisted of:

1. Confrontation, which challenges personal encounters with the world. The topics in this step concern the students' consumption and whether the consumption improves life quality.
2. Exploration of the status of current sociocultural realities. The topics in this step concern what the students' consumption habits are and who the stakeholders in their consumption are.
3. Evaluation and gaining awareness of reality. The topics in this step concern what the possible consequences of their consumption are.
4. Transformation of understandings, situations and practices. The topics in this step concern what the possible solutions for improvement are.

Questioning the fields of reflective inquiry about consumption culture

The different perspectives on reflective inquiry about consumption will guide the interpretations of whether reflections on consumption habits, their effects on life quality, stakeholders, consequences and habit improvements, operate within or aim to transform established fields of consumption and reflective inquiry. The researcher in this project asked questions about why students should learn to practice reflective inquiry, and how this can contribute to education for sustainable consumption (United Nations Environment Programme [UNEP], 2010). Lutnæs (2017) developed this framework through a review of key texts on reflective inquiry (Dewey, 1933 [1910]; Freire, 1970; Schön, 1983) and systems-oriented design (Sevaldson, 2011). These key texts describe reflective practice as inquiry that involves a state of perplexity with critical consciousness of un-preferred situations as transformable. The overall aim was to develop a reflective inquiry practice based on established practices for reflective inquiries, which could enhance students' skills to rethink and transform patterns of unsustainable practices of product consumption (Lutnæs, 2017).

The construction of data about teachers is not part of this research, but examples of how the framework may be used in teaching practices are included in the paper. The first example encompasses confrontation about the gift economy (about why we buy gifts to those we love when the environmental and social costs are not included). This had the aim of encouraging sustainability on the micro-level of everyday habits. The second example consisted of confrontation about how ideas of newness drive consumerism without improving life quality. This example had the aim to promote sustainability on the macro-levels of economic and social systems. Both confrontations included an exploration phase with GIGA-mapping in a collage with text and images, evaluation and transformation phases, with exploration of future scenarios concerning improvements to the situations (Lutnæs, 2017). Thus, the examples for teaching practice operate within the established practice of reflective inquiry, but aim to transform established fields of consumption practice.

The construction of data about students' development of skills to rethink and transform unsustainable consumption practices were not included in the research (Lutnæs, 2017). Thus, the students' potential learning outcomes were based on the inquiry framework and the examples for teaching practice, which thoroughly scaffolded the students' development of skills to rethink and transform their consumption practice. However, although the aim of the framework was to strengthen the students' competence within a specific reflective practice, the students' learning outcome from using this practice may be broader than that. This is because, in learning processes, students employ their critical thinking, judgement, will and imagination. Through this they develop their knowledge of the topic (Maus, 2020). Furthermore, through the GIGA-mapping of the potential consequences of their consumptions, the students also experienced each other's ways of performing the reflective practice. Thus, the students participate in the development and establishment of their fields of reflective inquiry on consumption culture.

Summing up the reflection practices

The three selected frameworks for promoting students' reflection in design education have similar nature, but also their differences. Descriptions of the three selected frameworks show that they have different aims, focuses of attention, steps and topics of reflection. By extracting and thematically analyzing the topics of

reflection described in the frameworks, a pattern concerning how the focus of attention affected the reflection topics emerged. Moreover, that the use of the topic of reflection on action were richer than only why and how, because reflections of what of actions also occur frequently. The main results were:

1. The topics concerning the how of action were emphasized in reflections on design products, while the questions about the why of action were emphasized in reflection on potential environmental impacts. In addition, the topics concerning does of action were emphasized in reflections on confrontations of environmental impacts from actions in one of the frameworks, but this does not make a pattern across the three frameworks.
2. The topics concerning the what of action were emphasized in relation to both design products and environmental impacts in the situations when multiple actions were possible.

The analysis results of the review are structured in the table below (Table 1).

Table 1: This table visualizes the most important aspects included in the analysis: the focus of attention; frameworks for reflection; and topics of reflection on the why, how and what of action.

<i>Focus of attention</i>	<i>Frameworks for reflection</i>	<i>Topics of reflection on the why, how and what of action</i>
Student– design product	Transacting relations: 1. Transacting with the idea of a product 2. Transacting with a material's capabilities 3. Transacting with remake techniques (Hofverberg & Maivorsdotter, 2018)	1. What kind of product to make from the reuse materials? 2. How can material be used for specific product? / What is a doable use of the reuse material? 3. How is a product constructed and crafted? / What is an appropriate technique for the making of the new product?
Design product– environmental impacts	Introductions and tasks in 1. Practice in craft-based design for sustainability 2. Product assessment after craft-based design for sustainability (Maus, 2019b)	1. Why are practices for product durability and efficient, circular use of resources environmentally considerate, and what is your use of these practices in your product? 2. Why are practices for product durability and efficient, circular use of resources environmentally considerate, and what is your use of these practices in your product?
Student– environmental impacts	Reflective inquiry to rethink consumption culture 1. Confrontation 2. Exploration 3. Evaluation 4. Transformation (Lutnæs, 2017)	1. Does consumerism improve life quality? 2. What are your consumption habits, and who are the stakeholders in your consumption? 3. What are the possible consequences of your consumption? 4. What are the possible solutions for improvement?

The analysis indicate that the potential for enhancing students' critical design literacy cannot be understood solely in terms of the use of how and why topics in reflection on the design products and their environmental impacts. This because the use of reflection topics are more nuanced. Moreover, the topics can be interpreted and rephrased to shift the focus between how, why or what topics of reflection on design products and their environmental impacts.

However, the critical reflection also relates to questions of whether one operates within established fields of practices or aims to transform them, when working with the design products and their impacts on the world outside the school studio. This is a more compound issue, because the students, teachers and researchers in general education have different perspectives on what the established practices of the field are. Therefore, this review leads to discussions of different perspectives of how the frameworks for reflection help students operate within established fields of practices and to transform them. Thus, these frameworks' potential to support students' development of critical design literacy.

Critical design literacy through reflection in design

This research paper started with the concept of critical design literacy and the aim of studying how three frameworks for reflection in design education can support students' development of the critical design literacy competence. The results of this study indicate that the focus of attention on the design product or its potential environmental impacts influence the topics of reflection. Topics concerning the design products focus on the practical how of action, while topics about environmental impacts focus on reasoning about the why of action. In addition, reflection topics about what of action were employed when multiple actions were possible in relation to both design products and environmental impacts. The discussion showed that the review of why-

and how-topics in reflection only illuminate one aspect of how to support students' development of critical design literacy.

The discussion of whether the frameworks for reflection support students' competence to operate within established fields of practice as well as to transform them are more complex. The researchers, teachers and students have different perspectives on what the established fields of practice are, and the discussion must conclude that all three frameworks for reflection in design have the potential to support the students' capacities to operate within, question and transform their field of practice.

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Encountering development in social design education

Critical approaches for global social design education

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Design for social good is an area of design in which designers focus on social problems. One way of teaching this type of content is through classes with an international component that mimics an international development project, where students work as a consulting team for an organization in a developing country. However, this type of class sometimes replicates problematic structures in international development such as neocolonialism, the perception that knowledge comes from the Global North. This paper details a workshop that was created to disrupt the negative narratives in this kind of global social design project, such as the design saviour narrative, by introducing elements from critical pedagogy such as critical reflection, examining bias and positionality, introducing ethnographic techniques, and intentionally flipping the power dynamics of the collaboration. Over a two-weekend workshop, students at an American university collaborated with students at a university in the Caribbean. Instead of going through the entire design process, this short class focused on the tension and unfamiliar roles that the students played when the students from the Global South were tasked with identifying issues of their colleagues and other participants from the Global North. The American students expressed their discomfort at being 'studied' at several points during the two-session design workshop. This paper aims to help other educators create learning experiences where students examine their positionality, privilege, and biases, while also creating a space for them to practice humility and reflect on power dynamics in international design work in a very intentional way.

Keywords: Decolonizing design, social studio, pluriversal design, design ethnography, design for development

Introduction

In a design school somewhere in the Global North, a design educator or design student is excitedly describing a social design class where they have collaborated with someone in the Global South. In another school, another person is excitedly planning for a new exotic experience in Kenya... Uganda... Ethiopia... Bangladesh, Cambodia, Brazil, Ghana, Ivory Coast, Guatemala, South Africa, Rwanda, Tanzania, Belize, Ecuador, Haiti. Social design is the use of design to address social problems (Janzer & Weinstein, 2014). The focus of many of these classes is on access to modernity and development for people in the Third World, inner cities, or in rural towns, and they are often built on models of international development with the assumption, as Arturo Escobar wrote in 1995, that Western standards and paradigms are the benchmarks for people in need of development (Escobar, 1995). Many social design classes include fieldwork and cross-cultural collaboration with design students from the Global North creating solutions to problems in the Global South. These classes prepare design students for future work in the social realm where they seek to promote social change rather than merely focusing on the design of artifacts (Janzer & Weinstein, 2014). There is value in global social design classes since they provide a context for designers to learn about and practice cross-cultural collaboration and skills and methods from anthropology, ethnography, and other social science disciplines. International cross-cultural collaborations can give students a broader view of the world, as they expose students to real-world challenges in a complex environment, and give students skills that they need for collaborative work. However, sometimes the design of these classes can perpetuate the narrative that people in the Global South need to be 'saved' by people in the Global North, promoting neo-colonialism and saviourism.



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Social design classes that are inspired by international development are at times presented as best practices in design education, such as in the course Design for Extreme Affordability, which is co-hosted by Stanford's business school, engineering school, and design school. In this class, students design products and services that aim to address the challenges of people in the developing world, while also creating business models to bring these solutions to market (Anzilotti, 2018). This type of class often used development principles and approaches such as a focus on modernisation, need, participation, and rights (Smith & Laurie, 2011). If this approach becomes more popular in future design education, then curricula that promote reflection on power dynamics, hubris and humility, and the harm of saviourism could also be needed to counteract the impact of the approach. More global and cross-cultural collaboration in design education requires a greater understanding by both design students and educators of factors such as cultural biases, cultural differences, and their impacts on cross-cultural teams, as people with different cultural backgrounds, cognitive biases, time orientation, and worldviews work together (Rau, Guo, Qie, Lei & Zhang, 2020).

The 'savior' narrative is derived from "White Savior Industrial Complex", a term coined by Teju Cole in 2012 as a critique of the activism of Westerners to support people in developing countries. His critique is of the superficiality of the approaches used in providing this support, the failure to understand the complexity of local contexts, and the fact that a 'nobody from America or Europe' can get the emotional satisfaction of becoming a 'godlike saviour' while operating under the banner of 'making a difference' (Cole, 2012). This saviorism morphs according to the context and is sometimes white saviourism, creative saviourism (Arenyeka, 2018), digital saviorism (Shringarpure, 2015). Development work that encourages this godlike saviourism of unfortunate 'others' is neocolonial as it replicates colonial structures and messages such as the message that the Global South needs to be saved. The field of development is often neocolonial as it replicates and sustains many of the unbalanced power relations from colonialism, where colonialism there is the unbalanced relationship between the coloniser and the colonised, in development there is relationship is the unbalanced relationship between the donor and the beneficiary (Kothari, 2005).

Some social design classes mimic the design of international development projects and employ a consulting structure where students act as design consultants for a local agency. International development is based on a linear notion of economic evolution, in which some places need to 'catch up' and the people who are already 'developed' have the knowledge and expertise that can be given to others to help them to catch up (Kothari, 2005). Development projects often observe a certain directionality in expertise. British development agencies, for example, would rarely hire an expert from Latin America, the Caribbean, Africa, or Asia as consultants for in the United Kingdom (Kothari, 2005), yet a European or North American consultant in the aforementioned contexts would be familiar and unremarkable. While a design class that borrows from international development and international volunteering can foster an awareness of social justice, equity, and global citizenship issues among students (Smith & Laurie, 2011), it can also mimic the challenges of international development work. One of these challenges is neocolonialism with the centering of the knowledge and expertise within the Global North (Smith and Laurie). Design neocolonialism (Janzer & Weinstein, 2014) occurs when the outsider perspective is privileged over the insider perspective in the creation of solutions to local problems. Another challenge is parachute consultancy. Parachute design practice is when a designer or team creates and proposes a solution from an outsider's perspective (Janzer & Weinstein, 2014). In these projects often the knowledge of the external expert is valued because of the positionality of the expert, making the knowledge legitimate because of who the expert is and where they come from (Kothari, 2005).

The understanding of both power and culture during design education could hopefully produce designers who are more critically aware of how their own cultural biases and the complexity of designing for people from a culture that is not their own (Pargman, 1999), as well as the power that may be derived from their positionality, could impact the design process. This greater awareness would also then be accompanied by mechanisms to remedy bias (Pargman, 1999), so that designers could produce better solutions that are relevant to the contexts in which they are practicing, limiting their own pre-existing social and technical biases (Friedman & Nissenbaum, 1996; Pargman, 1999).

Methodology

For this class, the instructors sought to create a pedagogical experience as a critical response to design classes that mimic development consulting and could be perceived to be rooted in neocolonialism and neoliberalism. The aim of the class was to create and provide alternative models for international collaboration for the students' consideration as they eventually moved into professional practice. We hoped to promote a critical awareness among the students that would lead to more thoughtful cross-cultural collaborations in the longer term, as well as to build an aptitude for cultural sensitivity that students would carry with them into their professional lives. The desired critical awareness was promoted through reflexivity throughout the short experimental class. We sought to address some factors that we considered very problematic in the design of the consultancy-inspired 'design for social good' type classes, such as the lack of attention to power and positionality and the unidirectionality of expertise in classes inspired by international development. We aimed to do this by focusing on dialogue, positionality, relationality, and by flipping the direction of the expertise in the project, so the students from the Global South would have more agency than the students from the Global North.

Introducing critical pedagogy concepts in social design education

We were inspired by critical pedagogy and built the curriculum around critical reflective practice, transformative learning, critical design practice, and critical conscientization. Brazilian educator, Paulo Freire, is considered one of the founders of critical pedagogy (Giroux, 2010). One of the aims of this approach is to create environments that support students to make better moral judgments and to become engaged citizens (Giroux, 2010). Conscientization is one of the key theories of Freire, aimed at developing social consciousness through the process of reflection and action, which is generally focused on empowering the poor in a developing country context (Lloyd, 1972), even though the students at this university fit a different demographic profile of the demographic in Freire's focus, we felt this approach, promoting critical reflection and awareness of social incongruencies in the structure of design projects would be appropriate. Critical reflection is the ability to reflect on an event in the midst of the experience (Blount, 2006). It requires the ability to both zoom in and zoom out to understand the details and their impact on the social environment (Blount, 2006). Like Freire's conscientization, transformative learning seeks to expand the student consciousness, so that they will question problematic assumptions, frames, and expectations seeking to make them more inclusive and reflective (Mezirow, 2003).

In designing the class, the professors identified several challenges of global social design courses where students from the Global North work in Global South contexts, such as:

- the over-problematization of the lives of people from 'exotic' places, without the reflection on the problems that exist in one's home country.
- the promotion of 'parachute' design practice and 'design neocolonialism' (Janzer & Weinstein, 2014) as best practices. In these types of projects, student designers receive messages that it is acceptable to drop into a community that is not one's own, propose ideal solutions, and then leave. practice, presenting an illusion that fast design where designers swoop in and whip out a solution works.
- the perpetuation of narratives about poverty or lack of expertise in the Global South. These classes seem to imply that problems in the Global South are easier to solve and are waiting to be solved by people from the developed world, perpetuating common stereotypes and promoting white saviorism.
- the lack of critical interrogation of who else is doing work in the communities that enter, who else do outsiders need to partner with, and what gives the outsider the 'right' to be doing this work.
- the lack of acknowledgment of the power dynamics and tensions in cross-cultural collaboration, with a lack of acknowledgment of the outsider privilege that might allow greater access to outsiders than a local team.

Description of the class

The two instructors, who were based at a university in Northern California, partnered with an art and design professor and the business school at the University of the West Indies in Trinidad and Tobago to co-design and teach the joint class with students from California. Over two Saturdays in April 2019, the teaching team based both in California Bay Area and in Trinidad and Tobago, students through a series of activities/exercises with the aim of helping students understand themselves and to be able to better understand others. The course began with about thirty students but ended with eighteen. Nine students from California and nine students from Trinidad and Tobago completed the two-day workshop. Both groups were composed of students from diverse academic backgrounds including undergraduate and postgraduate students with backgrounds in the humanities, social sciences, art and design, and business. Students applied to be part of the experimental workshop.

The class was originally called “Solving First World Problems”, and was designed as a possible alternative to more neocolonial approaches that are sometimes seen in design classes that involve international collaboration between stakeholders in the Global North and the Global South. The exercises focused on positionality, reflection, self-awareness, understanding the local context, and empathizing with others. Given the brevity of the class, approximately sixteen hours of in-person instruction, the content stopped at the formation of the problem statements and did not move into ideation or prototyping, since this would not be feasible in such a short class if ample time were to be given to reflection and discussion.

The instructors opted to focus on the start of the design process examining building relationships, practicing ethnographic skills, and understanding positionality as an insider or outsider. The work in the class, therefore, did not reach the solution phase. The class was pitched to students as an ‘anthropology’-based class where students would understand how to build relationships and the tension between insider and outsider statuses in community work. Insider and outsider statuses are described as **emic** and **etic** perspectives in anthropology. **Emic** and **etic** are two different approaches when trying to explain social realities observed while conducting fieldwork in anthropology and other social sciences. An *etic* perspective is the perspective of the observer, while an *Emic* perspective is the inside perspective or that of the studied social group (Morris, Leung, Ames & Lickel, 1999).

In creating the short class, the professors intentionally flipped the direction of the collaboration by designing a class where students in the Global South had more ‘power’ to make decisions than the students in the Global North. They were the ones who would lead the discussion, ‘diagnoses’, and determine the preliminary design direction.

The students were placed in cross-cultural teams with at least one team member from each location. They communicated via Zoom and WhatsApp over two weeks. Though this was a design class, they focused on the process of collaboration and their self-awareness growth. Reflection on positionality and relationships was the main focus of the class.

Miner’s (1956) popular, satirical anthropology text, ‘Body Rituals of the Nacirema’, in which he writes about suburban life with language that an ethnographer uses to describe an ‘exotic’ tribe, created a starting scenario for discussion in the class.

The students were asked to reflect on several questions individually and in their small groups throughout the workshop. These questions aimed to make the students reflect on how they would understand a local context, culture, and to see how their own biases might impact these perceptions. The questions were:

- How would you go about trying to understand the local context?
- Describe the other person’s culture (based on their preconceived assumptions)?
- How would you try to increase your understanding of the local culture of the other place?
- If you were talking with someone from [the other place] what would you do to understand the culture better...
- How might my positionality affect how I see the user’s point of view?
- I used to think Now, I think... (This was a final reflection to document any change in their point of view)

The responses were recorded by the students in a shared slide presentation and discussed within their small

groups and the whole group.
Some of the key activities are described in the below (Table 1).

Table 1. Key activities from the class.

Pre-class	No Words Conversation icebreaker on WhatsApp, Send pre-class design brief + optional readings
Day 1 – Morning	Warm-up activity Framing + design brief review Logistical matters How to conduct an interview (understanding the natives of Silicon Valley / Humans of Silicon Valley) Interview preparation Conduct Interview 1 Quick Debrief of Interview 1 Conduct Interview 2
Day 1 – Afternoon	Understanding + communicating local context exercises (as an insider or outsider) Develop a point of view statement Reflection and debrief Wrap-up Day 1 + Preview Day 2
Day 2 – Morning	Warm-up stoke Overview of Day 2 Positionality Exercise Revisiting POV statements
Day 2 – Afternoon	Formulate “How Might We” statements Rounds of Brainstorming Create and record presentations Reflections and closing

Pre-class activity:

Collecting life stories through images and video

Students were instructed to shoot photos and videos from their regular daily lives on Thursday, April 11, 2019. They were asked to capture at least 20 images or videos from different times of the day. These images would then be used to have a wordless conversation with one of their classmates from another culture. They were asked to capture images that would show their emotions, surroundings. Environment, people, and objects they interact with, and the activities that they engaged in throughout that day. They were encouraged to take casual photos and not overthink the process, but rather to just document that specific day.

No Words conversation

Students were assigned a partner before the class. They were given an activity aimed at getting them to know each other before the first class. This activity was called a “No Words conversation. They had to complete the No Words activity, using their phone and WhatsApp. Students could not call each other. On WhatsApp, student A would send a photo or short video from their collection of images. Student B would then be required to respond to that photo with an image or video from their collection that they felt was related to Student A’s image or video. Student A would then respond with another image or video. For example, one student might send an image of eggs that they had for breakfast, and the student who received it would respond with a photo of another image that included the colour yellow, e.g. their child’s toys, making a connection between the colour in the two images. They would have to keep this visual conversation going as long as possible and use the conversation to understand more about their partner’s life and culture. They were also encouraged to use a form of active looking and listening while looking at the photos even though they were not allowed to use words or emojis.

Class Day 1

A scenario was created where the students from Trinidad and Tobago were consultants with Decol Consulting. They had been hired by a development agency called Emergeathttps://doi.org/10.21606/drs_lxd2021. Emergeaid had to understand an imaginary foreign country called Acirema, that was at risk. There were problems of increasing inequality, rising authoritarianism, a complete breakdown in civility. Decol Consulting and its consultants had to study the Nacirema, an ethnic group in the Vale del Siliconio (Silicon Valley). They hired local collaborators at a University in the Bay Area to help them to understand the local context better. The students at the Californian University were the local consultants who served as a bridge between the foreign consultants and local culture.

Understanding positionality

The students were reflected on their positionality using The Positionality Wheel (Figure 1), which was created by the author in 2019. This is an activity created to help designers and researchers reflect on their identities and their teams' composition before starting their work. The wheel was developed around elements that could help a researcher write a positionality statement. This activity encourages all participants to reflect on their identity from more visible factors such as race, gender, age, and other less visible facets, such as ability status, class, education, and even their languages.

To use the tool, participants reflect on the 12 elements of their identities. They then reflected on the worksheet individually. The students were introduced to the concept of positionality to understand how their positions as insiders or outsiders to the context affected their understanding of the context as well as the types of solutions they would propose.

Positionality Worksheet

12 things about me that help me see the water that I swim in!

A positionality or reflexivity statement can help you understand who you are. These characteristics can be both strengths and weaknesses as they offer insights that others cannot see, or they can cause you to make assumptions that are not true.

Greater self-awareness can help you to maximise strengths and minimize weaknesses.

Research is not objective, because researchers are not objective. Your background frames how you conduct research.

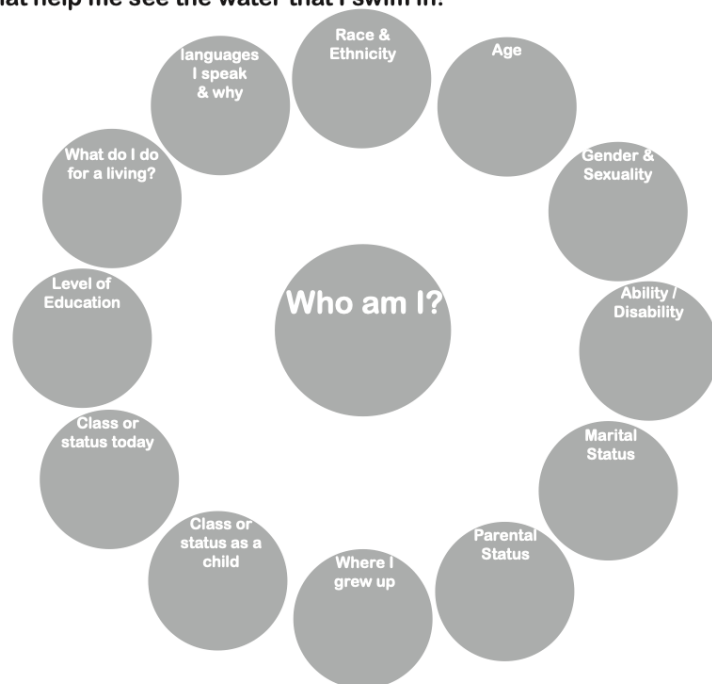


Figure 1. An example of the Positionality Wheel worksheet, that the students received to facilitate reflection on their identity and positionality. Source ©2019 Lesley-Ann Noel

Interviews with Locals

Local people from the California Bay Area were drafted for interviews. Interviewees were given some preliminary instructions on how to use the remote platform and who would be interviewing them via email. One whole group interview was conducted with a resident of the San Francisco Bay Area. The students from Trinidad and Tobago were encouraged to lead the questioning. In their teams, Californian students were interviewed about their experience of living in the Bay Area by the Trinidadian students. Groups conducted 2 - 3 interviews and then examined the themes they heard across interviews. Prior to this activity groups were briefed on how to build rapport during an interview and on ethnographic research skills. The local interviewee was asked about identity, home, and day-to-day life, how did they connect with people, passions, and future goals.

Learning to understand each other by revealing preliminary biases

Students were asked to reflect on their impressions of their own culture and the other culture at the end of the first day after listening to interviews with people from Silicon Valley, but before they started working together in their groups. Students were asked how they would go about understanding a local context. They were asked to describe the culture of Silicon Valley in particular since that was the context of the design challenge. They were asked to reflect on what had informed their impression of the place. They were asked

how they would increase their understanding of the context. They were then asked the same questions about understanding Trinidad. They completed a reflection in an online document where they could read everyone's responses.

Here are some student reflections on each place:

Silicon Valley:

1. The culture seems to be entrenched in tech, innovation, and starting companies and businesses. Money and wealth are of extreme importance. A lot of focus on success.
2. My description is largely based on how Silicon Valley is portrayed in the media, specifically the tv show Silicon Valley. Both interviews also validated my perception.
3. To increase my understanding of Silicon Valley I would need to conduct more interviews or have more conversations with people that are from different sectors in Silicon Valley so that I can learn from different perspectives. Immersion in Silicon Valley could also provide a better understanding.

Trinidad:

1. The culture of Trinidad is based on fusion and diversity in people, language, foods, and festivals. People seem easy-going and fun-loving.
2. My description is based on living in Trinidad. When I lived outside Trinidad it was often very important to differentiate ourselves from other Caribbean countries.
3. Sharing stories and experiences of people from Trinidad. Documenting and sharing more of my own day-to-day experiences that allow a better view of life in Trinidad not attached to local rituals, festivals, or a tourist experience. Encourage people to visit and immerse themselves in the Trinidadian experience.

Point of View Statements

After the group interviews, students analyzed what they heard and used the insights to create problem or opportunity statements. The groups were instructed to use an *etic* perspective or the perspective of the observer. Therefore, the students from Trinidad and Tobago led the 'diagnosis' of the problem. Here is an example of an insight from the conversation:

G needs to expand his connections to people outside of his professional community because he wants connections for when he possibly moves away from Silicon Valley, he values cultural affinity, this might also improve his personal and professional life.

The insights from the interviews highlighted themes such as the need for opportunities for social interaction, lack of identification with the dominant culture of Silicon Valley, the competitive nature of Silicon Valley, and the need for greater personal connections.

Post-workshop Student Reflections

In their reflections, students emphasized the need to create a space for differing perspectives in cross-cultural collaborations. Even though they recognized the similarities, several students highlighted the importance of creating space for different perspectives to get a more complex vision of a possible solution. Another student noted that international collaboration is possible but different. She recommended that to have a meaningful collaborative experience, collaboration must be approached with respect for the culture of others and an open mind. The humility to recognize that they did not know everything was a repeated theme in several reflections. Several student teams pointed out the importance of having a sense of humour throughout cross-cultural work to make collaboration easier. Despite technical difficulties, miscommunication, and other eventualities, keeping a lightness about the class made the collaboration smoother.

My biggest takeaway from the insider-outsider class was just how important empathy is at every stage of the process, especially when you are uncertain as to what you're heading into and how important humor is in connecting. ... in our group humor turned out to be a way in which we connected most easily. ... What surprised me the most was that it isn't essential that you know a great deal about another culture in order to learn about and connect with the people in that culture. It also provided me with a new way of seeing my new role as an insider from the perspective of an outsider, and I think the continual swapping of that role is what breaks down the boundaries.

Student X from California.

It's difficult to have outsiders coming in and scrutinising your culture, while they come with the best of intentions and they're there to solve the problem. Sometimes I wanted to hide the problem because I

only wanted to show them the best side of California culture. ... Throughout the course of the two weekends, my perspective on international collaborations changed because I thought it was going to be really different to connect across cultures... Once we hit our stride as a team, it didn't make a big difference who was an insider and who was an outsider.

Student Y from California

Discussion

This class aimed to create some tension around power by shifting more of the decision-making power to the students who would typically have less power in this type of engagement. The impact of this was seen where the students in California expressed some discomfort in being studied. The aim in creating this tension was to encourage plurality of thought, to promote an understanding of the value of diverse perspectives in the same problem, and to challenge the often-unstated assumption that knowledge comes from one direction. The class was grounded in decoloniality and pluriversality and the works of theorists like Boaventura de Sousa Santos (2013) and Arturo Escobar (2017).

In shifting the power in the class, the aim was to begin a departure from the typical 'Western-centric' design of international collaborations. Trinidad and Tobago, however, is still a Western country, so this is just a small departure. Boaventura de Sousa Santos (2013) posits that the understanding of the world far exceeds the Western understanding of the world. One aim then of educators seeking to create classes around international collaboration could be to foster a type of slow collaboration that deliberately challenges students' Western-centric worldviews, and encourages them to be curious about other people, their thoughts, and their ways of being. According to Santos, the Global South is often considered a 'metaphor for human suffering' and not a source of theory'. Therefore, the class is an example of the type of cognitive justice that Santos advocates for that is needed for social justice, and this cognitive justice is reached through the 'ecology of knowledges' and 'intercultural translation' (Santos, 2013).

The class structure included many reflective pauses where students reflected on their assumptions and what they felt in the interactions about the various processes of the design research process. These moments of reflection lead to the transformative learning process articulated by Mezirow (2003), where students challenge their own problematic frames, assumptions, and expectations. In student reflections, it was evident that they were able to see how both emic and etic perspectives could be leveraged to create more complex understanding of problems. The 'local' students from California also shared how uncomfortable they felt when only an *etic* perspective was used since they felt that the outsiders did not fully understand or appreciate the intricacies of the local context. This was the type of reflective thought that the professors had hoped would be achieved, and that this type of reflection would make students reflect critically on current and future design practice.

Though this pilot was very short, it is possible that the balance between the insider and outsider perspectives of students from the Global North and the Global South could in the future lead to deeper insights and innovative solutions.

Conclusion

Social design education has the potential to produce transformative learning and social change. Social design also includes closer collaboration with people across difference, and brings with it challenges related to positionality, power and neocolonialism, and other problems that may be associated with the field of international development. Therefore, this potential can only be achieved with the intentional crafting of pedagogical experiences that shift dominant narratives and promote a critical awareness of social issues and the development of a critically reflective practice leading to critical design practice.

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Exploring practices of critical design literacy

A comparative study of two lower secondary school design project

Eva Lutnæs

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We have destabilized nature by design. The Anthropocene epoch requires a fundamental redirection of the purpose of design and design education. This empirical review explores two design projects—*Repair* and *Ecovillage*—at the level of lower secondary education in Norway. The review examines ways in which pupils are challenged to question, rethink and transform unsustainable practices of everyday living. A methodological framework consisting of four narratives is used to identify design skills and discuss the potential empowerment of critical design literacy. In the *Repair* project, pupils' question practices of the fashion industry and responsible consumption while they design kits for mending clothes. The *Ecovillage* project challenges pupils to explore how architecture can lower carbon footprint and enable shared-living. The *Repair* project empowers the pupils to transform unsustainable practices present in the roles of consumers. The *Ecovillage* project asks pupils to claim a role as redirective designers and discern the possibilities of architecture to nudge change in our modes of being in this world.

Keywords: critical design literacy, general education, empirical review, design skills

Introduction – exploring critical design literacy in a trilogy

Design holds a key agency in materializing and designing our lives, as well as what comes next (Fuad-Luke, 2009). In *Design for the real world*, design researcher Papanek (1971) critiqued contemporary design practices as harmful for the environment, and detached from the needs and lives of ordinary people. Papanek advocated for designers to adopt social responsibility and the concept of design ethics. Including design in any curricula fuels change by exploring situations and satisfying problems. Facing the complex problem of overcoming a world made unsustainable (Fry, 2009), the question of change through design and design education becomes an ethical one. What situations are worth changing? What are the socio-ecological consequences of a new product, city district or service? What problems should be left unsolved? The 2013 DRS//Cumulus-conference in Oslo framed design education for all as a game changer. To promote sustainability and address global challenges, professional designers are dependent on critical consumers, a design literate general public (OsloMet, 2013, Nielsen et al., 2015). The general public—in the roles as consumers, investors, user participants or policy makers—holds the power of transforming unsustainable patterns of living by the products they voice and opt for, and the way they use and dispose of products. How might design education empower the general public in claiming their position as a well-informed and critical mass?

Reviewing the scientific discourse on design education for a general public, one would find different and rather conflicting ideas of what design literacy is, as well as on the purpose of design literacy for society and individuals. Lerner (2018) framed design literacy as the ability to understand and make use of a canon of aesthetic form. Her focus remained on the positive aspects of visual-spatial learning for an individual's cognitive growth and their advancement to a higher-level of abstract thought and creation. Economic competitiveness and success in a globalized market is another goal of introducing design literacy to the general public. Design literacy is framed as skills of creativity and innovation (Canina et al., 2013; Martin, 2009; Vande Zande, 2013; Wright, Davis, Buccolo, 2013). Deemed meaningful in terms of business, the contribution of design education as creative capital satisfies just one out of three mutually reinforcing pillars of sustainable development (United Nations, 2002). Economic competitiveness as the purpose of design literacy echoes



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Sterling's (2001) critique of education as mainly reinforcing unsustainable values and practices by educating to 'compete and consume' rather than to 'care and conserve'. In the article, 'Evolution of the Mind: A Case for Design Literacy' (Pacione 2010), a question is raised regarding what it means to be design literate as opposed to being a design professional. Pacione (2010) named "the act of arranging how something looks" as a stereotype of design to stamp out in order to convince a majority of leaders in business and government to support design thinking both in companies and as a vital part of general education (p. 11). Pacione (2010) put forward the basic skills of inquiry, evaluation, ideation, sketching, and prototyping. He describes an iterative process of uncovering and satisfying unmet needs as core design capacities, but no attention is given to the socio-ecological consequences of satisfying needs.

Looking back at initial arguments on why design awareness represents an important area of educational development, it becomes evident that design education was not introduced as a means to shape marketable innovations or beautiful forms; in fact, it was intended to meet "urgent need for the survival as well as the happiness of mankind" (Archer, 1973/2005, p. 21). Cross (1982) promoted design as a basic way of knowing, along with the humanities and sciences. He justifies design in general education by the way in which it develops abilities to tackle ill-defined real-world problems. Baynes (1974) and Cross (1982) frame the role of design education as empowering the individual for participation in daily life and society. Educating tomorrow's problem solvers to meet the challenges created by unchecked economic growth, pollution and inequity, shortcomings can be found in design literacy as a means of mastering a canon of aesthetical form—or as mastering the designers' toolkits for innovation. This article is the third in a series (Lutnæs, 2019; 2020) exploring what it means to educate for *responsible* design literacy. The trilogy takes up on the ideas of design as a basic way of knowing to participate in society (Cross, 1982) and the ideas of the critical consumer in promoting sustainability and addressing global challenges (OsloMet, 2013; Nielsen et al., 2015). The first article explored the scientific discourse, the second article explored a curriculum text, and the third article will turn the lens towards educational practice. In the following, contributions from the first and second article will be briefly introduced, as they are vital in understanding the background and methodical framework for the current and third article.

Framing the concept design literacy – four narratives and a definition

Educating the general public in design literacy can catalyse both environmental protection and degradation, human aid and human-made disasters. This is all contingent upon how *design literacy* is defined and how the scope of design is framed. The definition of design literacy is crucial. Reviewing the scientific discourse up until 2018, no explicit definition was found in regards to design literacy for the general public to support critical innovation and a possible move towards sustainable societies. The first study (Lutnæs, 2019) in the trilogy, articulated a definition by reviewing key texts' narratives (Soini & Birkeland, 2014). Identifying and reviewing the key texts in the scientific discourse (Nielsen & Brænne, 2013; Green, 2014; Christensen et al., 2018), shared ways of explaining design literacy—what it is and how to cultivate it amongst learners—were looked into. The review derived four narratives amongst the authors that were deemed vital to educate for design literacy:

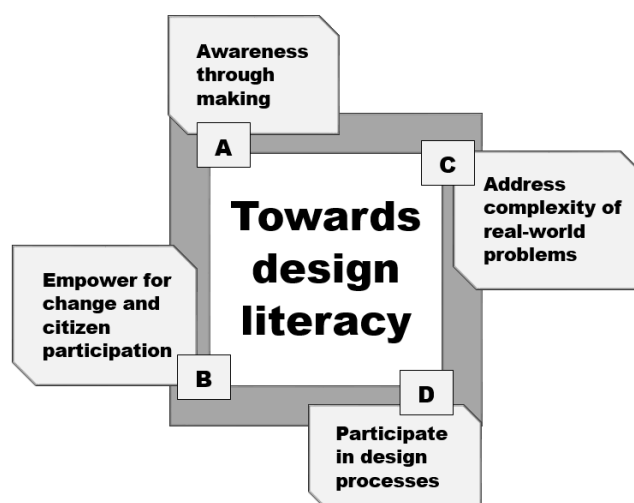


Figure 1. Four narratives on how to cultivate design literacy

The narrative (a) combines awareness and making. All authors emphasize the importance of first-hand experience with materials to educate a design literate general public. As makers, pupils learn how to transform materials and use visual elements to voice and advance ideas for the future (Green, 2014; Christensen et al., 2018). Through the mode of making in physical materials, the demand of time and energy in production becomes a first-hand experience to pupils, and further, what it takes a product to become solid, functional, and interesting to use over time (Nielsen & Brænne, 2013). The first-hand experiences provide an arena to draw pupils attention to the plural context of materiality and the socio-environmental impacts of human-made artefacts. The narrative (b) promotes design literacy as a game changer in encouraging more responsible participation from citizens. It is a shared narrative amongst the authors concerning the importance of providing pupils with a sense of agency and tools to question, rethink and transform the world. Pupils are empowered to voice their ideas and differing perspectives in the design of a garden (Green, 2014), or to criticize and change the system in how they acted as consumers and producers (Nielsen & Brænne, 2013). The narrative (c) frame the capability to address complexity of real-world problems as a key feature of design literacy. Pupils are challenged to map and navigate conflicting interests and dilemmas embedded in design practices and solutions. The capacity to embrace complexity and explore solutions that contribute to a better future is a shared goal among the three texts. The narrative (d) is endorsed by the authors as enabling pupils to adopt a designer's tools for innovation and to understand how designers think. In the 2019 article, I draw on insights provided by the four narratives to attempt a definition of design literacy empowering the general public for socio ecological responsibility:

Being design literate in a context of critical innovation means to be aware of both positive and negative impacts of design on people and the planet, approaching real-world problems as complex, voicing change through design processes and judging the viability of any design ideas in terms of how they support a transition towards more sustainable ways of living (Lutnæs, 2019, p. 1303).

The definition corroborates Pacione's (2010) in terms of the ability to voice change through design processes. It also corroborates with Cross (1982) in tackling real-world problems. The crucial difference is the inclusion of awareness of the wider social and environmental impact of design and critical reflection, and this is brought about by judging how design ideas might advance more sustainable ways of living. Both the narratives and the definition will evolve as new academic texts address design literacy as part of general education. The first article in the trilogy reviewed the scientific discourse thus far and made a contribution by breaking the concept of design literacy into tangible pillars to identify and discuss design skills for the general public to claim a position as a well-informed and critical mass.

Mapping out design skills in a new national curriculum in the subject Art and Crafts

In the second article (Lutnæs, 2020), the four narratives are explored as a methodological framework to map out design skills and identify areas of curricular advancements. The real-world example for the study is the new Norwegian National Curriculum for the compulsory subject, *Art and Crafts*, in primary and lower secondary education (Ministry of Education and Research, 2019). The national curriculums serve as a regulation; competence goals describe what pupils should be able to master after completing a given year of study in each subject. As part of the national curriculum reform the definition of competence was changed to include 'the ability to reflect and think critically' (Norwegian Directorate for Education and Training, 2017). The study (Lutnæs, 2020) investigates how the competence goals in *Art and Crafts* respond to the conceptual change towards critical thinking. It maps out the potential of embedded design skills to educate responsible citizens and problem solvers of tomorrow.

The narratives (a) *Awareness through making* and (d) *Participate in design processes* are commonly tackled in the competence goals. In contrast, the narratives (b) *Empower for change and citizen participation* and (c) *Address complexity of real-world problems* are scarcely represented. The well-represented narratives (a/d) promote reflective processes in the design studios of primary and lower secondary schools. Narrative (a) calls upon the effort of the pupil to ensure minimum environmental damage and to strive for a product that becomes solid, functional, and interesting to use over time. Narrative (d) allows pupils to adopt tools for ideation and evaluation. The two scarcely represented narratives (b/c) hold the potential of shifting focus from skillful, reflective actions within the design studios to the real-world problems of society and responsible citizenship. The second article (Lutnæs, 2020) concludes with describing a need for developing educational resources to support teachers in advancing more transformative practices that recognize and challenge the dominant ideologies embedded in everyday situations. It calls for design responses that care for both people and the planet. The third article is a response to the need for educational resources and it explores two real-

world design projects from a teacher's perspective.

Method of inquiry – mapping design skills from an insider's perspective

The current study makes use of the four narratives (Lutnæs, 2019) as a methodological framework to map out potential empowerment of critical design literacy within two of my design projects at the level of lower secondary education. The two design projects, *Ecovillage* and *Repair*, were developed and integrated into educational practice in the 2020-2021 school year. I move between different modes of practices as I work both as a teacher in lower secondary education and as a professor at the university. My pupils are well aware of my double role as a teacher and an academic. In this study, the role as a teacher serves as a 'mediating component' (Dunin-Woyseth & Nilsson, 2012, p. 3) between the field of academia and the field of general education. This study reports strictly on the design of the projects from the teacher's perspective. Pupils' views, experiences or products are not part of the empirical data.

This study is situated as an empirical review from an insider's perspective and the development of educational resources is regarded as a creative practice. Riis and Groth (2020) described the value of the approach as follows: "Research through creative practice allows for experiential and embodied knowing from inside the practice to be documented, analysed and distributed in a way that an objective or distant approach will not facilitate" (p. 4). The design projects described in this study are not design researcher sketches of possible projects. They are real-world examples of a teacher from inside the practice of lower secondary education. The projects are designed with real pupils in mind. It takes into account knowledge of what motivates their learning and what is doable within the professional learning environment and conditions of a lower secondary school.

The *Ecovillage* and *Repair* projects were not planned with the four narratives in mind. Rather, they serve as a framework for a retrospect mapping of design skills. The study serves as a pilot on how the four narratives may have the potential to crack open educational practice for empirical review. A pilot, however, is only the beginning. The claim of Dunin-Woyseth & Nilsson (2012) is acknowledged regarding a double judgment of both practitioners and scholars through negotiations between connoisseurship and criticism. The double judgement points to the challenge of practice-based research and how research results must comply with the demands of both the world of academia and the world of professional practice (Dunin-Woyseth & Michl, 2001, p. 2). The key to approval comes through how the four narratives may facilitate dialogue and critique of design education among the stakeholders. In order to explore the full potential and assess research results, the methodological approach must be scaled up (e.g. by comparative review of design skills embedded in briefs across countries and levels of education or research on collaborative development of educational resources). With reference to Eisner (1975), Dunin-Woyseth & Nilsson (2012) describe the role of connoisseurship and criticism in practice-based research as follows: "to do research we could say that the competence of the connoisseur – the ability to perceive and appreciate nuances in a particular field of practice – has to be combined with the competence of the critic – the ability to disclose and communicate characteristics and qualities to a broader audience" (p. 7). Eisner (1975) explains the educational function of criticism as follows: "Its aim is to lift the veils that keep the eyes from seeing by providing the bridge needed by others to discern the qualities and relationships within some area of activity" (p. 8-9). The bridge in this study is the descriptors of the four narratives (Lutnæs, 2019), and the disclosed nuances stems from being a practitioner in lower secondary education. The four narratives are used as a shared structure to voice different design skills embedded in *Ecovillage* and *Repair*, followed by a discussion on the potential empowerment of pupils' critical design literacy.

The Ecovillage project

Since my very first year as a lower secondary teacher (school year 2015/2016), I have had the privilege of collaborating with local housing developers to design an architectural competition for the level 10 pupils (age 15-16). My drive for collaborative competitions is to showcase *Art and Crafts* relevance to society and future career opportunities for the pupils. Further, to fuel pupils' intrinsic motivation for school projects. The briefs for the competitions were always based on a case the housing developer was facing at the time. The interest of the housing developers in interacting with pupils were twofold. First, they were able to get ideas and inspiration from how youngsters approached the case. Second, there was a factor of motivating talent in pupils, potentially leading them to consider pursuing careers in carpentry, architecture, or entrepreneurship. The briefs were designed according to the competence goals in the current national curricula. They also sought to accommodate visions and terms set by the housing developer.

After a successful collaboration with the housing developer *Nordbolig* on massive wood apartments for a zero-

emission neighbourhood, *Nordbolig* initiated a new competition for the next school year based on a planned ecovillage at Møystad farm. I approved the initiative and sent a first draft for a competition on small family homes and senior apartments. The project leader at *Nordbolig* responded with a far more challenging and future-oriented idea; they wanted the pupils to design shared-living spaces for the ecovillage (Figure 2). Their vision for the shared-living spaces was to enable mixed-use, inclusive social interaction, and to lower the overall carbon footprint of the 50-60 inhabitants in the ecovillage. Furthermore, every home could be smaller—and therefore, greener—if people had access to shared facilities such as guestrooms, gyms, home offices, tool sheds and workshops.

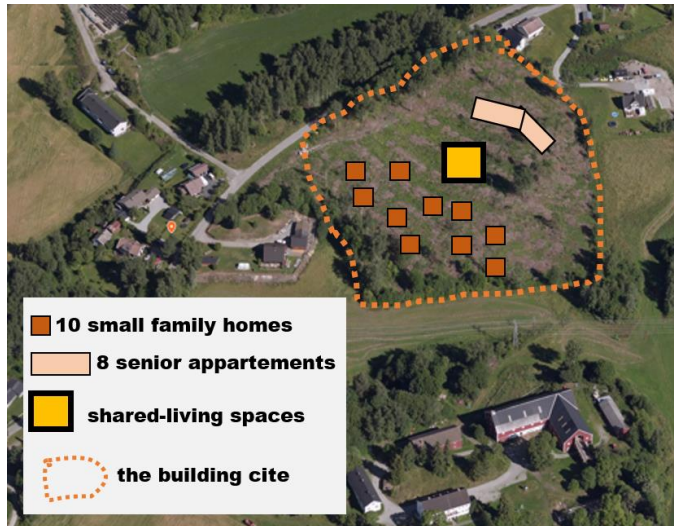


Figure 2. The building side for the Ecovillage project at Møystad farm

Nordbolig, the housing developer, provided a PowerPoint to familiarize pupils with the concept of an ecovillage, the site, criteria for the competition and a list of possible features for the pupils to combine with their own ideas. Pupils decided whether they wanted to sign up for the competition. All pupils (N: 100-120), however, were required to participate in the *Ecovillage* project as one of three compulsory 18-hour projects for their final grade in the subject *Art and Crafts*.

Reviewing the *Ecovillage* project with the four narratives as a lens, the twist from the project leader pushed it towards narrative (b), *Empower for change and citizen participation* and narrative (c), *Address complexity of real-world problems*. By making the case for the level 10 architectural project a planned ecovillage in the municipality, the pupils engaged in a real-world problem. The idea of designing shared-living spaces, however, added layers of complexity to the task. The pupils were challenged to map out how shared-living spaces could foster well-being and a sense of community, as well as contribute to combat climate change. In their design, the following conflicting interests and dilemmas emerged as pupils addressed the task: What are people capable of sharing? What conflicts might emerge with co-ownership? Should the shared-living spaces be accessible for the public or exclusively for the ecovillage community? Do the shared facilities offer something for all generations? Are the shared-living spaces making a noteworthy contribution to lowering the overall carbon footprint? The concept of shared-living challenged the pupils to fundamentally rethink ways of engaging with neighbours. It expanded on neighbour relationships, not as ‘small talk over the hedge’, but within the context of day-to-day living. Pupils gained experiences for change and citizen participation, and this was based on how architecture potentially enable—and disable—fellowship amongst people, as well as how it facilitates new ways of being. The shared-living spaces idea called on pupils to voice the perspectives of a whole village, not the singular individuals’ visions for a home.

The narrative (a), *Awareness through making* is relevant to the ecovillage in how pupils gain first-hand experiences with scale and floorplans. Pupils connected to the physical realities of the site in terms of where the sun rises, but also what facilities the size of a room would enable. When they voiced and advanced their ideas, they needed to interconnect the interior and the exterior of the building and envision the spatial experience of the elements they put into play. The socio-environmental impacts of architecture is integrated in the *Ecovillage* project. This was evident through the ways in which by how the pupils were asked to further explore and derive suggestions on what the more environmentally-friendly choice would be (i.e., heating, materials, and interiors of the shared-living spaces), and how their suggested facilities for shared-living would

combat social isolation. The narrative (d), *Participate in design processes* is the backbone of the project; it was reflected in how pupils were led through a process of discovery, concept sketching, peer-critiquing of solutions, prototyping and refining details based on feedback from peers and teacher. This was all performed prior to the delivery of the project in the form of a digital presentation and critical review of their final design. In their critical review, they were asked to judge the viability of their own design and how their ideas for shared-living spaces could enable inclusive social interaction and lower the overall ecovillage carbon footprint.

The Repair project

The *Repair* project—designing kits for mending clothes—encompasses the fashion industry as a context to the level 8 pupils (age 13-14) learning in the *Art and Crafts* studio. The project ran for 20 hours and was one out of three compulsory projects in *Art and Crafts* for the 2020/2021 school year. The first phase of the project is exploratory, and it calls for pupils to learn basic skills of embroidery, techniques for stitching pieces of felt together and methods of making functional locking mechanisms for the repair kit. The pupils practiced a range of embroidery stitches of their choice; they used their acquired crafts skills to form a fabulous decorative creature on the repair kit. The exploratory phase culminated in the making of a paper prototype for the shape, decor and functions built into the repair kit at a 1:1 scale. The paper prototype provided the entry ticket for the pupils to cut fabric and create their repair kit. Feedback from peers and the teacher were integrated as a means of continuous improvement of craftsmanship, design ideas, user friendliness and variety in exploration of techniques.



Figure 3. My teacher sample to test the project and the old repair kit that sparked the idea for the *Repair* project

As a corresponding learning path to pupils' process of designing and making repair kits, a second assignment was introduced. Through this, I aimed to bring the fashion industry and the pupils' everyday life as consumers into the textile studio. The second assignment was divided into three tasks: How can you contribute to a lower negative impact on nature related to clothing? What are your pleas for the fashion industry that might change the system to take better care of nature and humans? Pupils were also asked to choose one of their own garments and visualize the garment's journey from "cotton seed to post-use". This was done by researching possible processes, peoples and countries involved. To enable the pupils to address the second assignment, I gave lectures on the environmental impact of the fashion industry, working conditions, facts on Norwegian clothing consumption and resources on how to mitigate overconsumption and textile waste in everyday living. Narrative (d), *Participate in design processes* is relevant to the *Repair* project in that pupils are led through a product design process of exploring possibilities within form, function and textile craft techniques towards a final product. The first-hand experiences with materials are a key to educate for design literacy in narrative (a), *Awareness through making*, and this key is situated within textile crafts in the *Repair* project. The pupils experienced the amount of accuracy and effort required to make even, solid stitches. Furthermore, they were able to see how the choice of materials, size and shape affects the functionality of the repair kit. In the exploratory phase, pupils were encouraged to take care of tools and materials to reduce environmental impacts in the making of the repair kit. As a teacher, I demonstrated how to place the pattern near the edge of the fabric, the appropriate length of the embroidery thread and what happens to textile scissors that have been used to cut paper. Efficient use of materials is something the pupils needed to learn, as squandering is more often than not a lack of knowhow rather than carelessness.

The second assignment expanded the *Repair* project from narrative (a)/(d) to narrative (b), *Empower for*

change and citizen participation and narrative (c), *Address complexity of real-world problems*. The pupils were challenged to embrace complexity by uncovering and documenting every possible detail regarding their own garment. They did not address the complexity of a real-world problem through this exercise. Rather, they began to scratch the surface on the complex system involved in fashion and how it relates to clothes they wear. It is worth noting that exploration of solutions is made by tasks that challenge pupils to voice ideas that might change the fashion industry for the better. When the pupils turned the lens on their own behavior as clothing consumers and suggested how they themselves could contribute, the task began to interlink with narrative (b) on responsible citizen participation.

Discussion

The project briefs are mediating artefacts that transform the studio into a learning space (Orr & Shreeve, 2018) with shared commitments. Including design in any curricula fuels change by exploring situations and satisfying problems. According to Simon (1996): “Everyone designs who devises courses of action aimed at changing existing situations to preferred ones” (p. 111). Choosing which situation to change is the concern of the design educator when planning a new brief. It would make a vast difference whether the design educator ask pupils to design products to increase sales, or to design products that improve quality of life while combating climate change. The latter asks pupils to relate to the socio-ecological consequences of design. In design education, the project briefs indicate expectations that arise in order for pupils’ design ideas to be evaluated as valuable. In *Ecovillage* and *Repair* the challenges of the real-world were brought into the lower secondary education *Art and Crafts* studios. The concerns of the ecovillage brief were social isolation and the carbon footprint of housing, and the concerns of the repair brief were overconsumption and socio-ecological impact of the fashion industry. The final products consisted of repair kits for mending clothes (level 8) and concepts for shared-living facilities (level 10). These design responses hold the potential of transforming unsustainable practices of everyday living. They represent both an alternative and a critique of current socio-cultural realities. The projects explore counter-narratives related to design activism (Fuad-Luke, 2009) and designers’ role as redirective practitioners (Fry, 2007; Manzini, 2009). The project briefs allow pupils to encounter two distinctly different learning spaces and roles for the in their design processes.

Empowering for redirective practices

In the *Repair* project, I have identified the situation worth changing—in this case, fashion waste—and decided on a repair kit as the design response. The outcome of the design process is predetermined, and the counter-narrative (Fuad-Luke, 2009) was a product of my decision. Accordingly, the repair kit displays the socio-ecological responsibility and a design response for sustainable consumption of a teacher, not the pupils. The pupils’ design process did not address the complex real-world problem of fashion waste. Rather, it was concerned with what possible forms, functions and textile craft techniques needed to be combined to create the repair kit. In the *Repair* project, the textile studio is consciously turned into an arena for demonstrating eco-efficiency and care. It became a location that allowed pupils to adopt practices by first-hand experiences with tools and materials. The hours the pupils spent practicing embroidery and basic use of a thread and needle enabled them to mend holes and resew loose buttons, thus saving their clothes from a premature sortie. With their new repair kit, they got the tools needed to act as responsible consumers and redirect clothes from waste. The design and making of functional repair kits empowered the pupils with redirective practices and critical design literacy in their roles as consumers. The *Repair* project transformed the textile studio into a learning space for pupils to discover how small shifts in practices reduce environmental impacts, as well as newly-learned concepts of care and eco-efficiency to apply in daily tool use and resource consumption.

In the *Ecovillage* project, the design process was far more complex and open-ended (Christensen et al., 2018; Smith & Iversen, 2018). The pupils took the main role and decided which features they wanted to offer as a design response to the visions from the local housing developer. In addressing the task of shared-living spaces, the pupils engaged directly with the socio-ecological consequences of their proposed solutions. They also prioritized what situations were worth changing. In their design responses, the pupils addressed different real-world problems and confronted value conflicts such as: “What is the socio-environmental impact of shared sports facilities, compared to shared facilities for farming and processing of food?” Unlike the design response asked of level 8 pupils, the level 10 design response brought about the concept of design ethics, described by Chan (2017) as: “the broader philosophical question concerned with how one should live, or what a good human life consists in” (p. 186). The design response called for by the *Ecovillage* project challenged the pupils to claim a role as redirective practitioners in the design process, specifically concerning how we live together

as neighbours. This was done through creative compromises (Van de Poel, 2015) that combated social isolation and lowered the carbon footprint. It also discerned possibilities of architecture to nudge change in our modes of being in this world.

Empowering for critical reflection

The final products—repair kits and concepts for shared-living facilities—were not the only tasks pupils needed to perform and create within the projects. The potential empowerment of critical design literacy was reinforced by the questions embedded in the project as the pupils worked their way through the design process. A transition towards more sustainable ways of living depends on individuals with the courage to care and fundamentally rethink definitions of human needs and desires (United Nations Environment Program, 2011). Judging the viability of design ideas as a general public, and knowing what makes the more sustainable alternative, is difficult. However, there is always the availability of critical reflection through questioning consequences, beneficiaries and reasons. Critical reflection addresses the ‘why’ of action and the reasons and consequences of what we do. It aims to produce a profound change in our attitudes and actions, while reflection without this prefix operates towards improvements within an established field of practice, or the ‘how’ of action (Mezirow, 1990). Critical reflection empowers individuals to address the ‘why’ of design, and it is crucial in allowing large-scale changes.

In the *Repair* project, the second assignment introduced questions that required pupils to shift focus from designing and crafting to the fashion industry and their own consumer behaviours. These questions served move pupils’ concerns to the wider social and environmental impacts of fashion. From this, a case for critical reflection was created. Pupils called the system into question and considered alternatives (Brookfield, 2010) towards more sustainable modes of consumption, trade and production. The pupils challenged the pre-established regimes through words, they ‘named the world, to change it’ (Freire, 1970). In the *Ecovillage* project, challenging questions emerged in the studio as pupils navigated conflicting interests and ethical concerns towards their final shared-living spaces concept. In the review of their own design, they were asked to judge the viability of their own design in terms of how it could support a transition towards more sustainable ways of living. In doing so, they took into concern both environmental protection and human well-being. The questions embedded in both *Repair* and *Ecovillage* challenged pupils to connect real-world problems with empathy. It provoked them to rethink our ways of being in this world as societies and as individuals.

This study explores two design projects—*Repair* and *Ecovillage*—at the level of lower secondary education in Norway. The research poses the question of how pupils are challenged to question, rethink and transform unsustainable practices of everyday living. Both projects disrupt the commonplace habits of inevitable human practices, of which concern getting dressed and building shelter. Exploring three key texts on reflective inquiry (Dewey, 1933; Freire, 1970; Schön, 1983), a structure was identified regarding four shared phases (Lutnæs, 2017). All three texts describe the experience of a temporary collapse in the ordinary script of life as the fuse of reflective inquiry. The first phase is an experience of confrontation (1) that calls a person’s own habitual patterns into question. In the next phase, current sociocultural realities are explored (2) to enhance knowledge of the situation. The information provides a backdrop to evaluate (3) prevailing practices and habits of mind in an evaluative phase that aims to gain new understanding. Change is the ultimate goal of the process; it occurs when new understanding enables a creation of transformed (4) actions and habits of mind. Reviewing recent research on critical literacy, Bishop (2014) synthesized a similar cycle of moving from disruption of commonplace habits, interrogation of multiple viewpoints, identifying issues, undertaking actions, reflecting upon actions taken and creating visions for future projects.

Both design projects challenge the ordinary script of life and pupils act upon the disruption by promoting alternative visions. In the level 8 project, *Repair*, pupils use their words to express alternative visions and suggest change in both the fashion industry system and their own consumption patterns. The *Repair* project holds the potential of empowering pupils to navigate complexity and ethical concerns of fashion as consumers. Furthermore, by using their newly acquainted craft skills and repair kits to mend clothes, new potential was created to affect change and action in transforming unsustainable practices. Unlike the level 8 pupils, the level 10 pupils promoted alternative visions via a design response. Through the role as redirective design practitioners, the level 10 pupils were challenged, and navigated both complexity and ethical concerns of shared living. By gaining first-hand experiences with design as a redirective practice, the *Ecovillage* project holds the potential of empowering pupils to discover design and designers’ role, coining visions and actions towards more sustainable ways of living.

Coda on the role of education empowering for critical design literacy

Transformation is a key concept in this article. The transition into a more sustainable model of society depends on citizens that act on their knowledge and design and implement large-scale changes. The favourable outcome of empowering for critical design literacy in general education is the critical citizen, or in other words: “individuals who are self-reflexive—setting themselves and their world in question—and have a deep concern for the lives of others” (Darts & Tavin, 2010, p. 241). On a note of concern, it must be added that a deep concern for nature is just as important as the concern for humanity. However, a teacher cannot prescribe new consumer habits and design activism amongst pupils, as the idea of influencing people’s behaviour in a predetermined way contradicts the essence of education (Wals, 2011). Therefore, the concept of ‘potential’—when interlinked with empowerment—is equally important. Another take on ‘potential’ is the four narratives as a methodological framework to crack open the practice of design education for empirical review. From a teacher’s perspective in this study, design skills and potential empowerment for critical design literacy have been identified in two different lower secondary school projects. Other researchers and design educators are welcomed and encouraged to explore the full potential and to discuss further advancement of the framework.

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