2013

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Jelle de Boer

2013

Boer, Jelle de
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Print: Ipskamp Drukkers B.V., Enchede, The Netherlands

ISBN: 978-94-6191-768-3
ISBN: 978-94-6191-770-6 (electronic version)

RIJKSUNIVERSITEIT GRONINGEN

Learning from video: viewing behavior of students

Proefschrift

ter verkrijging van het doctoraat in de
Economie en Bedrijfskunde
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. E. Sterken,
in het openbaar te verdedigen op
donderdag 13 juni 2013
om 9.00 uur

door

Jelle de Boer

geboren op 3 februari 1960

te Hemrik

Promotor	:	Prof. dr. E.O. de Brock
Copromotor	:	Dr. P.A.M. Kommers
Beoordelingscommissie	:	Prof. dr. M.J. Goedhart
		Prof. dr. M. Valcke
		Prof. dr. W. Kuiper

Dankwoord

Bij het afronden van een promotie denkt menig promovendus vaak terug aan hoe het zover heeft kunnen komen. Ik echter niet: ergens in 2005 luisterde ik naar de inaugurele rede van de toenmalige lector Bert de Brock en een dankwoord gaat naar hem. Hij was net geïnstalleerd door de voorzitter van het College van Bestuur van de Hanzehogeschool Groningen (HG), Henk Pijlman. Hij nodigde geïnteresseerden in een promotietraject uit om met hem te komen praten. Die uitnodiging heb ik gelijk opgepakt en ik heb een afspraak gemaakt. We hebben toen in een zeer vruchtbaar gesprek ruim het dubbele van de geplande tijd besteed aan het inventariseren waarover mijn promotieonderzoek zou moeten gaan. Gespreksonderwerpen waren mijn interesses, eerder onderzoek en zijn lectoraat. Een duidelijk beeld kwam er nog niet, wel dat het iets met video, log files en meerwaarde voor het hoger onderwijs te maken zou moeten hebben.

Een versnelling in het traject kwam door twee ontwikkelingen. Ten eerste kwamen er subsidies vrij van de toenmalige minister Plasterk van onderwijs. Hij stimuleerde de professionalisering van personeel in het hoger beroepsonderwijs (HBO) door het subsidiëren van onder andere promotietrajecten voor docenten in het HBO, een dankwoord dus ook naar hem. Dit bracht een einde aan de soms op een bedeltocht lijkende zoektocht naar subsidies.
Daarnaast kwam er ook een einde aan het lectoraat van Bert de Brock. Hij kreeg een niet te missen kans om professor te worden aan de Rijksuniversiteit Groningen. Voor de Hanzehogeschool Groningen een vervelende ontwikkeling, maar voor mij een goede, want ik had nu ook gelijk een promotor.
En wat voor één: zijn eerste opdracht aan mij was om gelijk maar een publicatie te gaan maken over mijn onderzoeksresultaten in het eerste jaar. Die opdracht heeft mijn werk als promovendus meer focus gegeven. Ik was ook zeer trots toen mijn eerste bijdrage aan een congres werd geaccepteerd en niet lang daarna in aangepaste vorm als artikel in een journal werd geplaatst. We hadden toen al besloten om mijn promotie op artikelen te doen en niet op één groot onderzoek. Over zijn begeleiding kan ik alleen maar lof hebben: altijd stond hij klaar, vooral voor de grotere zaken tijdens het onderzoek, een tweede dankwoord dus voor hem.

In de tweede helft van mijn onderzoek kreeg mijn onderzoek een iets andere wending. Het onderwerp ging zich meer op het leren van de student richten en we hebben toen de hulp ingeroepen van Piet Kommers als copromotor. Zeker dank ook aan Piet voor de zinvolle bijdragen die het onderzoek naar een hoger niveau hebben getild.

Ook een dankwoord aan Martin Goedhart en zijn vakgroep Instituut voor Didactiek en Onderwijsontwikkeling van de Rijksuniversiteit Groningen. Bij het begin van mijn onderzoek heeft hij een werkkamer ter beschikking gesteld. Deze kamer is voor mij regelmatig een oase van rust geweest en ook een plek voor wetenschappelijke discussies.

Dank ook aan Jos Tolboom, een groot deel van mijn promotietraject was ook hij promovendus. Een van de gepubliceerde artikelen in dit proefschrift hebben we samen, in een zeer prettige samenwerking, gemaakt. Ooit hebben we de afspraak gemaakt om na onze promotie weer samen te gaan werken. Zijn altijd positieve instelling en gemeende interesse zijn zeer belangrijk geweest voor de afronding van mijn promotie.

Dank ook aan Michiel Bodewes. Aan het begin van mijn promotie hebben we samen een bedrijf gehad, maar dat viel niet te combineren met een promotie. Wel zijn we doorgegaan met squashen en tijdens deze sessies heeft ook hij met zijn scherpe geest bijgedragen aan mijn onderzoek.

Ook een dankwoord aan mijn collega's Peter van der Steege en Gerhard Wentink op de HG die instructievideo's hebben gemaakt. Ook dank aan Dick Vink, Jan Postema en Rienko de Vries voor de techniche ondersteuning. Dank ook aan mijn kamergenoten. Naast mijn promotie was ik ook daar werkzaam en dat moet niet altijd een pretje zijn geweest. Als promovendus leef je even een paar jaar onder een steen. Dank dus aan Peter-Jan Hagedoorn, Bas van Hensbergen, Marco Krop, en Rob Willems. Natuurlijk bedank ik ook alle studenten die mee hebben gedaan aan mijn onderzoek.

Het allergrootste dankwoord ben ik verschuldigd aan mijn gezin: mijn zonen Lukas, Pieter en Rogier en mijn vrouw Renate de Boer-Luurtsema. Van hun kant en ook van mijn schoonouders heb ik altijd onvoorwaardelijke steun gekregen tijdens dit traject en die heb je ook hard nodig, want promoveren betekent soms ook doorwerken in het weekend en vakanties. Nooit een verwijt als in de vakantie weer eens een activiteit voor mijn promotie "moest" worden gedaan, nooit een wanklank als een klus weer iets later aan de beurt kwam. Dank ook aan mijn vrouw voor het eindeloos redigeren van de Nederlandse samenvatting en eindversie van het proefschrift. Vooral tijdens de vele wandelingen met mijn vrouw en onze hond Perra hebben we veel over mijn promotie bijgepraat en in de moeilijkere momenten heb ik daar erg veel steun aan gehad. Alleen in het laatste jaar zei ze een paar keer: "Nu mag het ook wel eens een keer afgelopen zijn".
En dames en heren: dat is het nu!

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Chapter 1
Introduction

This thesis is about learning from video. This research investigates students' viewing behavior while learning from instructive video. Secondly the revealed learning effects were related to the logged browsing sequences. In order to optimize the students' learning effects, an additional intervention that made the students aware of their typical viewing behavior was defined and analyzed for its subsequent effects.
At first, in section 1.1 the background of our research and the problem statement will be elaborated. In Section 1.2, the research questions will be discussed. Finally, the thesis structure will be introduced in Section 1.3.

1.1 Problem Statement

The initial trigger of this research project was the availability of log files from users of video material as nowadays common in education. The patterns in logged viewing sequences allow the researcher to characterize individual viewing behavior and eventually derive his/her learning style. The utilitarian scope is to finally find relevant parameters for an adaptive and personalized video presentation sequencer.

In higher education, the use of video resources has increased recently. Video modality is seen as attractive as it is associated with the relaxed mood like watching TV. Due to lower success rates, as will be explained below, improving learning from video becomes more and more important because a video – in contrast to a teacher - can be accessed anytime and anywhere. These videos are mostly accessed from a learning management system like Blackboard. These systems are mainly used in order to improve the communication between students and teachers. However, a large portion of a learning management system is only filled with general assignments for students in its native format. Much (personalized) functionality of these learning management systems is therefore not used at all.

At the same time, higher education in many countries (incl. the Netherlands) has become more competence-oriented. The amount of lessons has been reduced while students have to spend more time studying with (digital) materials on their own. These two developments did not lead to higher success rates in higher education. Moreover, the last years there is a tendency to even lower success rates. Half of the students do not finish the first year of their courses and the rest finishes it a few years later as planned.

Most of the projects that aim at higher success rates focus their attention on the scheduled lessons for students. Another way to improve the success rate of higher education is the use of video.
Video nowadays is increasingly used as an instructional tool in education. Students are instructed to enhance their individual learning skills from text rather than from video. Interacting with the control buttons of a media player provides students only with standard tools to interact (start, pause, and stop) with video and does not necessarily support the individual learning process. Therefore it becomes important to optimize the learning process of students from video.

Streaming video servers are nowadays frequently used to distribute video to students. These servers are logging event queues (pausing, rewinding, etc) in so-called log files. Just as in e-business, log files can be used for personalization and evaluation. In educational settings however, mining log files to gather more insight in viewing and learning patterns of students has hardly been employed. Log files are mainly used for detecting errors in the infrastructure and will be deleted as quickly as possible as they may reduce overall system performance. If the viewing behavior of a student potentially influences his or her learning outcomes, we can also use these loggings for personalized feedback to the student.

The need to improve the effectiveness of learning by using video lessons therefore becomes more urgent as web-based materials contain more and more videos and also more and more control tools for the learner. The web has created a much more autonomous and flexible student attitude. If we want to improve the sequential aspect of students' learning from video, it is inevitable to typify and understand how students differ in their learning preferences.

The experiments as described in this thesis are part of a research project with the goal to gain more insight in the learning and viewing patterns of students from video. This understanding aims at the development of videos with a higher learning effect, a more adequate control for the user as a learner and finally a better integration of video in education.

The following problem statement has been formulated at the start of our research project:
What are the characteristics of a framework for an e-learning environment that offers real-time adaptive responses students' individual learning style?

1.2 Research Questions and Methods

This research thesis performed four experiments and resulted in four subsequent journal articles (Table 1.1).

The following four research questions have been formulated during the research project:

1. Which viewing scenarios can be recognized in log files from streaming media servers?
Learning management systems log data from students while they are logged in to the system. However, no data of the viewing session from a student is logged. Streaming media servers log a lot more data of this viewing session. Not only the session length is recorded but also interaction events of a student with a video like pausing and rewinding.
In the first experiment as described in Chapter 2, the logged viewing patterns of 50 students and twelve instruction videos were analyzed in an explorative research. Four scenarios were recognized:

- the *one-pass* scenario, where a student watches a video in one-pass (uninterruptedly) from the beginning to the end
- the *two-pass* scenario, where a student watches a video again after finishing the first time in one-pass
- the *repetitive* scenario, where a student watches parts of a video repeatedly
- the *zapping* scenario, where a student skips through an instructional video at intervals of relatively short viewing times.

The viewing behavior of the *zapping* scenario is similar to the learning behavior of a student with an *undirected* learning style from Vermunt (1992). According to Blijleven (2005), a broken link between the learning task and learning process could be the underlying factor of this zapping behavior. Furthermore, if we want to make learning management systems more personalized we might use this learning style of a student. Therefore, learning processes and its possible link with learning styles were investigated further in the second experiment.

2. Can we use log files from streaming media servers in order to determine learning processes from students and is there a link with the learning style model from Vermunt?
In the second experiment as described in Chapter 3, the viewing behavior of students was recorded in a controlled environment (usability lab). The log files from streaming media servers were analyzed and semi-structured interviews were held with the students after the learning task.
It demonstrated that students' learning processes could be monitored through the use of log files. However, there was no clear link between viewing scenarios of students and its underlying learning style. Vermunt's distinction of learning styles not only includes a cognitive- but also a self-regulating and a motivational perspective. Therefore, our focus changed from learning styles to more pervasive personality traits like cognitive styles and the short-term memory of students. This brought us to the third experiment.

3a. Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory?
The third experiment as described in Chapter 4 consists of two parts. The first part (3a) focused on the cognitive perspective and investigates whether the students' viewing behavior is determined by pervasive personality traits. The second part (3b) focused on the awareness about viewing styles.
The students' viewing behaviors were investigated in a controlled environment (usability lab). Semi-structured interviews were taken from the students after they performed the learning task.
This experiment showed that viewing behavior with streaming video of students is not strongly correlated with the more pervasive personal traits such as short-term memory capacity and learning styles (style-oriented). Students however proved to be flexible in changing their viewing behavior.
3b. Can viewing style awareness contribute to higher learning outcomes? An awareness instruction in the second part about their viewing behavior was given to 19 students in an experiment and this enhanced their learning outcomes. Both parts of this third experiment (3a and 3b) have been published in one article (Chapter 4).
This second part (3b) of the third experiment has been up scaled-up in terms of more students in the fourth experiment. Furthermore, the possible role of students' prior knowledge on the topics was investigated in terms of revealed learning effects. This brought us to the fourth experiment.

4. *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?* The fourth experiment (described in Chapter 5) also proposes a new model that addresses both style and strategic elements in the manifest viewing behavior of the student. The model was based on metacognition and recent notions about the use of learning styles in education. The model was applied on a group of 115 students (including the 19 students from the previous experiment) in order to see whether learning effects differ among students with narrow or broad repertoires of viewing behaviors.

Students who demonstrated only one viewing behavior attained lower learning effects than students with multiple viewing behaviors. Also, students who demonstrated a strategic viewing approach attained higher learning effects. However, students with low prior knowledge of the topics proved to enhance their metacognitive skills less. Furthermore, some students developed marking techniques with the mouse in the media player to watch video more strategically.

During the four experiments we used the following research methods:

- Questionnaires for the first experiment
- Explorative analysis of the log files for the first and second experiment
- Observations in class room for the second experiment
- Semi-structured interviews with students for the last three experiments
- Qualitative analysis of video recordings of students from a usability lab, also for the last three experiments

The second part of the title of this thesis: *viewing behavior of students* has two meanings. The first one is about the viewing behavior of students. The second one is about our analysis of the video recordings in a usability lab: we were viewing the behavior of students.

The methods are described in more detail in the following chapters and appendices.

1.3 Thesis structure

The four articles – each presenting one experiment - will be presented in Chapters 2, 3, 4, and 5. Chapter 1 is this introduction. The discussion (Chapter 6) presents and summarizes all relevant results from the four experiments. Furthermore, we discuss the theoretical and practical implications of our research findings. Finally, we reflect on our research setup and discuss the needed further research.

Table 1.1: Thesis structure

Chapter:	**Main conclusions:**
Chapter 1 Introduction Problem statement, research questions, and thesis structure	
Chapter 2 How to interpret viewing scenarios in log files from streaming media servers Research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*	Four viewing scenarios were recognized: one-pass, repetitive, two-pass, and a zapping scenario.
Chapter 3 How to use log files from streaming media servers to determine learning processes Research question: *Can we use log files from streaming media servers to determine learning processes from students, and is there a link with the learning style model from Vermunt?*	Students' learning processes could be monitored through the use of log files. However, we found no clear link between viewing scenarios of students and their learning style.
Chapter 4 Using learning styles and viewing styles in streaming video Research question: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness contribute higher learning outcomes?*	Viewing behavior with streaming video of students is not strongly correlated to short-term memory capacity and learning styles. Students are flexible in changing their viewing behavior. An awareness instruction enhanced their learning outcomes.
Chapter 5 Viewing video for learning Research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*	Students who demonstrate a strategic or a multiple viewing approach attain higher learning effects than students with only one viewing approach. Students with low prior knowledge of the topics are less able to enhance their metacognitive skills. Some students develop marking techniques with the mouse in the media player to watch video more strategically.
Chapter 6 Discussion Findings, implications, reflection, and future work	

Chapter 2
How to interpret viewing scenarios in log files from streaming media servers

Jelle de Boer, Jos Tolboom

Hanze University Groningen, Faculty of Applied Sciences, The Netherlands

University of Groningen, Faculty of Mathematics and Natural Sciences, The Netherlands

International Journal of Continuing Engineering Education and Life-Long Learning*, 18,* 432-445 (2008)

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Chapter 6 Discussion Findings, implications, reflection, and future work	

In the following chapter, we focus on the following research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*

Learning management systems log data from students while they are logged in to the system. However, no data of the viewing session from a student is logged. Streaming media servers log a lot more data of this viewing session. Not only the session length is recorded but also interaction events of a student with a video like pausing and rewinding. With this additional data we can describe in more detail the viewing session of a student.

In the first experiment, as described in the following chapter, the logged viewing patterns of 50 students and twelve instruction videos were analyzed in an explorative research, in order to detect patterns in the viewing sessions.

Abstract

When video is offered to students in a Web-based Learning Environment through a streaming video server, digital traces of their viewing behaviour can be collected in log files. These traces can be linked to view behaviours like zapping. According to the literature, a zapping scenario could indicate the broken link between the educational task and the video. The analysis of log files from e-learning systems could tell us something about studying the behaviour. The subject of this explorative research is the possibly interesting patterns in log files from streaming media servers. The setting of the experiment was a polytechnic institute in Groningen (The Netherlands) and it involved three groups of students, 50 in total, who were taking a course on JavaScript. We focused on the relationship between the event clusters in the log files and their related viewing scenarios. The presence of zapping can indicate the need for improvements to either the instruction video or its accompanying task. Based on our analysis of the literature, previous experiments and interviews, we have defined four viewing scenarios: one-pass, two-pass, repetitive and zapping scenario. We found traces of these scenarios in the log files. Further research is necessary to link viewing scenarios to study the behaviour.

2.1 Introduction

This paper is structured as follows. In section 2 (theoretical background) we show why streaming video is beneficial to the learning process in general and we discuss examples of students' mouse-clicking behaviour (log file use) from the literature. Section 3 sets out the design of the experiment in detail. We show the results of this experiment in section 4 and present our conclusions in section 5.

Online streaming video servers are a recent technological development in the distribution of video. Because streaming allows for buffering and caching you can start watching while downloading the complete video. Recent research has shown that streaming videos can be used fruitfully in education, provided technical problems are overcome and the content is embedded in the curriculum in general and specifically in assignments (Hanna, 2000; Gibbs et al., 2001; Green et al., 2003; So & Pun, 2002; Boster et al., 2006; Fill & Ottewill, 2006).

Nowadays streaming video is being used more often in education. It is most frequently accessed in the digital learning (content) environment called a learning management system (LMS) or learning content management system (LCMS). Tolboom advocates a difference between the LMS and a web-based learning environment (Tolboom, 2004). One could say roughly that the difference lies in the content of the LMS used to offer learning possibilities to the student. Because of this difference, we will use the term web-based learning environment (WLE) when we refer to L(C)MS with content.

It is common practice in e-business to analyze customer click streams in web server log files to gather data on customer behaviour that enables firms to anticipate and respond to their customers' changing fields of interest. In addition to this sort of evaluation, it is also possible to distribute a personalized environment based on, for instance, click and buying patterns. In educational settings, the use of log files for data mining is not employed to any large extent (Hewitt et al., 2003). Log files are used mostly for detecting errors in the infrastructure and get thrown away afterwards because they reduce overall system performance.

Because students can also access videos on hard disks and CD-ROMs – less controlled environments with less opportunity for actual contact with the student – a need has arisen for learning about the student's progress, possibly through keeping track of digital traces like test scores, viewing start time, stop time, breaks and interruptions. Log files have been analyzed in specific situations for video accessed on local sources like hard disks or CD-ROMs (Van den Berg & Blijleven, 2002) but not yet in connection with video accessed remotely from a streaming media server.

An exploration of possibly interesting patterns in log files from streaming media servers is the subject of this experiment, which was conducted at the Hanze University Groningen (The Netherlands) and involved three groups of in total 50 students who were following a course on website development. Part of this course was dedicated to a frequently used technique for user-interaction called JavaScript. We produced 12 lesson videos on this topic varying in length between 5 and 13 minutes. Each video was accessed through a WLE connected to a streaming media server.

A WLE can be used to generate cumulative reports of all student visits to the different parts of a course (see Figure 2.1). However, it is not possible to drill down to specific data on individual viewing scenarios, for example one student looking for particular information on staff, because this data is lost or not even logged.

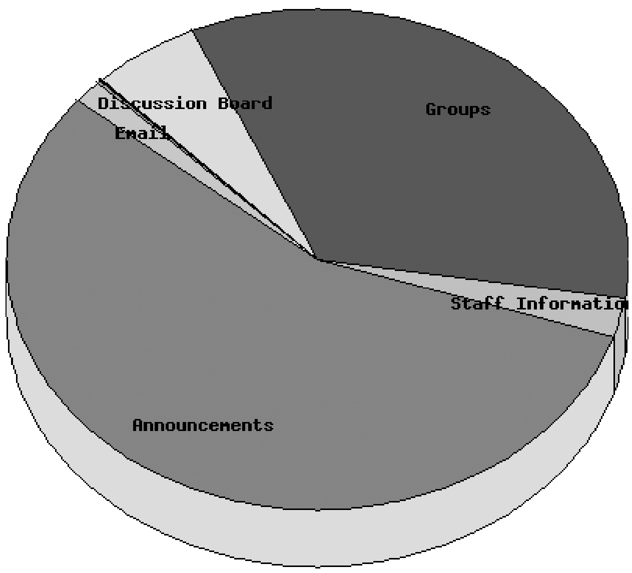

Figure 2.1: Cumulative report of student visits

We have gathered insights from log files from streaming media servers taken from a previous experiment (Liefers, 2004; Van den Berg & Blijleven, 2002), in which traces were detected that seemed to indicate that some students were skipping through a lesson video. At the time no connection was made to a zapping-like viewing scenario. Blijleven predicted that something similar to zapping could happen (Blijleven, 2005). Some multimedia cases he investigated proved useless as students were not given clear lesson tasks. Such a weak or even broken link between the lesson video and its task might cause zapping.

2.2 Theoretical background

2.2.1 The use of digital video

In this section we give the theoretical background for this explorative research. In section 2.1 we discuss why (streaming) video is beneficial to the learning process in general and in section 2.2 we discuss existing research on students' clicking behaviour in log files. We also define four viewing scenarios.

Before digital video arrived, videotape was widely used in education. Recorded lectures were already described in the 1970s (Gibbons et al., 1977). The advent of the digital era, with the introduction of video on CD-ROM and DVD, did not change the basic concepts or intentions of this specific application. The emergence of digital networks, like the internet, disconnected video-watching from a set time because the video can be watched at any time. It has also led to disconnecting the lesson, in some sense, from a set place (i.e. the classroom): the video can be watched on any computer connected to the internet. The use of streaming video has made this even easier, with its use of smart emission and compression techniques. These observations are all made from the student's point of view; in terms of Information and Communication Technology (ICT) from the 'front office or client side'. On the other side, however, in ICT terms 'back office or server side', the arrival of computer networks has created even more new possibilities: the analysis of log files from the servers that provide information to students.

In this investigation our analysis of log file data is concentrated on one specific server: the streaming media server. Supported by a survey and interviews with students, in this explorative analysis we have tried to characterize the nature of student clicking behaviour.

There has to be a meaningful link between theory and practice in education, as both social constructivism and gestalt theory explain. This meaningful link can be reinforced with video.

The theory of social constructivism (Vygotsky, 1978) has gained widespread attention. Its starting point is the formal theory of constructivism which is generally attributed to Jean Piaget (Piaget, 1950; Piaget, 1967; Von Glaserfeld, 1982). Constructivism articulates that learning is an active process, during which a student tries to interpret and understand his or her experiences. Interaction with the environment is of great importance because learning is seen as a social process that must take place in a realistic context that is both challenging and meaningful for students. Social constructivism emphasizes the importance of culture and context in constructing knowledge based on this understanding (Kim, 2001). Video can reinforce this realistic context.
If a student watches a video in one pass from the beginning to the end we call this viewing scenario a one-pass scenario.

Based on the work of Von Ehrenfels (Von Ehrenfels, 1890), Max Wertheimer (Wertheimer, 1935) describes the three main principles of gestalt perception as:

1 the principle of similarity
2 the principle of proximity
3 the principle of directionality.

We have translated these three principles in our research with respect to the use of (streaming) video as:

- *similarity*: the instruction in JavaScript demonstrated on the video resembles precisely the situation in which the student will be carrying out the assignment.
- *proximity*: by closely following instructions when working on the various tasks of the final assignment (designing a web form) students will perceive their activities as coherent. This is best achieved when video is used to illustrate the tasks.
- *directionality*: videos can clearly guide students towards the 'discovery thinking' they need to practice.

Korthagen & Lagerwerf use the term 'gestalt' to refer to cohesive wholes of earlier experiences, *role models, needs, values, feelings*, images and routines which are – often unconsciously – evoked by concrete situations (Korthagen & Lagerwerf, 1996; Korthagen, 1998; Korthagen, 2001). With the lesson videos we are trying to give students *concrete situations* in which they:

- gain a *role model* (teacher demonstrating JavaScript skills)
- learn to *value* the use of JavaScript and *see* the *need* for this functionality
- get a *visual* tutorial in programming *routines* with a specific tool – the *visual* aspect being important; compare this to the development of the 'graphic user interface' versus 'character-based user interface' (Soloway & Pryor, 1996)

Gestalt played an important role in the development of our educational material. It did not play a direct role in the research itself.

Verhagen describes some interesting research on the role of segment length in interactive video programmes (Verhagen, 1992; Verhagen, 1993). He distinguishes some typical information elements and examines their roles in the segment lengths chosen by a group of students. His goal is to formulate design rules for the lesson video. Although this is interesting for our research, when it comes to the design of our videos we took a different approach. We were interested in the students' viewing scenarios in themselves and took the instructional quality of the videos for granted. The quality of the lesson videos was rated by students in this research as being indeed adequate.

Educational materials represented on video need to obey the three principles (see above). For an application of these ideas in a multimedia context see, for instance, (Van den Berg & Visscher-Voerman, 2000). Gestalts ensure that in new situations students repeat behaviour that has given the desired effect in comparable situations. However, an appropriate method according to the student can be inappropriate according to a teacher. It is important that schools organize learning activities in such a way that students can become aware of their own actions in working practice. Critical reflection is very important if students are to develop an understanding of and knowledge about their behaviour and situations. Streaming video can play an important role in stimulating critical reflection, especially when the scenes of practical situations shown virtually on the video present cognitive conflicts for students. Thinking critically about the simulated problems will make students more aware of what is required in real working situations.

The very nature of the video medium allows students to repeat a virtual situation more than once. This is generally impossible in other less volatile learning media not as accessible as video (Cennamo et al., 1996; Abell et al., 1998). Repetitive viewing of practical situations allows students to understand virtual situations well and compare these with their own ways of working. If a student watches a video or parts of a video repeatedly, we call this viewing pattern the repetitive scenario.

The research by Hewitt et al. has shown that you can get students to develop 'habits of praxis' through the use of multimedia cases (Hewitt et al., 2003). In so doing, students adopt a critical reflection to adapt to the various contexts they will also encounter in real life. According to this research, presenting a single multimedia case is not enough to create a link between theory and practice. This is also confirmed by Blijleven (Blijleven, 2005):

> *'[By] adding a guiding task to a well-designed multimedia case it is possible to create a meaningful interaction between the case content and (…) practice. This means that a method is created for "bridging the gap between theory and practice" (cf. J. Shulman, 1992). The guiding task can be considered as the "road" on the bridge (multimedia case) that gives [students] the opportunity to connect theory and practice. (…) The "drivability" of the road depends on the way the multimedia case is embedded in the curriculum.'*

Multimedia cases with video offer a lens through which students can study realistic situations, assess ideas and connect their gestalts to new insights.

The function of a video component is threefold (Van den Berg & Visscher-Voerman, 2000). First of all, video has the function to demonstrate. Software tools in education can be demonstrated in this way through capturing some parts of their functionality. Secondly, video has the function to inspire. By providing an example of innovative education to students, teachers inspire students to experiment with these examples in their own educational work and in so doing contribute to their competences. The third function is to stimulate reflection and critical analysis of the professional working methods. By encouraging students to analyze critically and reflect on the way their real-life teacher acts, teachers can prevent students from simply copying a video teacher without forming their own opinion of the behaviour shown in the video.

We close this reflection by remarking that there is a considerable body of literature in which researchers are convinced of the value of lectures recorded on digital video and made available through a web-based learning environment (Day & Foley, 2006; Boster et al., 2006).

2.2.2 Students' clicking behaviour

Just as in e-business, in education taking place in the web-based learning environment (WLE), web server log files can be used for personalization and evaluation.

Shen, Yang & Han have presented their Data Analysis Centre based on an e-learning platform (Shen et al., 2002). Web-based learning enables many more students to have access to a distance-learning environment, providing students and teachers with flexibility. At the same time, current e-learning systems also pose many problems. For example, teachers cannot find out about the learning status of students and the teacher's assignment is independent of the student. It would help the teacher if it were possible to analyze students' learning patterns and to organize the web-based contents efficiently. The Shen system is smart because of its data-mining features and user-friendly through the visualized services it offers both teachers and students.

Log files are also used to construct adaptive systems based on principles taken from the Learning Design method developed by IMS Global Learning Consortium, Inc. (http://www.imsglobal.org/learningdesign). According to Iksal and Choquet, in the context of distance learning and teaching, the re-engineering process needs to provide feedback on the learners' usage of the learning system (Iksal & Choquet, 2005). They consider it important to interpret traces in order to compare the designer's intentions with the learners' activities during a session. They have presented a usage-tracking language (UTL). This language was designed to be generic and an instantiation with IMS Learning Design, the representation model they chose for three years' of experimentation. The design of an LCMS is connected to the structure of the log files. In this way it is possible to analyze the design of education tools in relation to actual use.

More viewing scenarios can be expected. According to Cennamo (1996) and Abell (1998) students watched a video a second time if they seemed not to understand it the first time around. Also, they could interrupt the video to start doing the assignment belonging to the lesson. In this experiment we could not detect such a scenario from the log files because our students did not have to authenticate themselves on the streaming media server. However, we surveyed the students involved and asked about their use of such scenarios in a questionnaire. We call this viewing pattern the two-pass scenario.

Log files alone are not enough to interpret data. The context of use should also be incorporated in interpretation. Pape, Janneck & Klein described how they used log file analysis to investigate whether using a computer to support cooperative learning systems corresponded to the didactical purposes. For example, they examined the use of a web-based system called CommSy as software support for project-oriented university modules. They presented measures to shape the context of computer-supported cooperative learning systems and other measures to support their initial and continuous use. They also showed how log files can be analyzed to show how, when and who uses a computer-supported cooperative learning system and thus help to validate further empirical findings. Log file analyses can only be interpreted reasonably well when additional data concerning the context of use is available (Pape et al., 2005).

Two aspects limit the possibility of finding patterns in log files through data mining and knowledge discovery. Firstly, log file analysis is generally used only for error detection in the underlying infrastructure and is sometimes discarded afterwards. Secondly, system performance is compromised by extensive (online) monitoring.

A review of the literature shows little investigation into the use of log files from streaming media servers. One reason for this could be that most researchers are unaware of all the useful events and item types that are recorded during a viewing session. Apart from technical information like the bandwidth used and processor utilization, other relevant events during a viewing session are recorded, such as pausing and restarting a video. However, current technical and organizational difficulties may be inhibiting researchers from designing and conducting such types of research.

A few participants' log files have been used in experiments (Van den Berg & Blijleven, 2002). Log file data were combined with other data from open interviews to trace back the participants' behaviour. One experiment showed that students demonstrated zapping behaviour when the link between the lesson video and task was weak or entirely lost.

In an earlier experiment (Liefers, 2004; Van den Berg & Blijleven, 2002), contrary to what you might expect from the theory, we found that more viewing scenarios than one-pass viewing can be detected from the log files of streaming media servers. For example, some students seemed to skip through the lesson video at regular intervals of relatively short viewing times. This viewing pattern resembles fast-forwarding through a video or zapping through a number of television channels. According to Blijleven (Blijleven, 2005) this could be the case. Students seem to be zapping through a video if there is a weak or broken link with the lesson task. We call this viewing pattern the zapping scenario.

2.3 Design of experiment

As this experiment involved the collection of log files, here we discuss the structure of these log files. The setting of the experiment is elaborated upon, as well as the embedding of the instruction videos in the curriculum.

2.3.1 The structure of the collected log files

Log files record behaviour data ('events') from the use of applications and web sites. For instance, a log file event can be a user requesting a web page from a web server (see Table 2.1). Collected data include such items as the IP address of the user's computer, the date and time of the web-page request and the web page the user was visiting before making the request for this web page.

Table 2.1 Some data from a streaming media server

C-IP	Date	Time	Starting point (in sec.)	Duration (in sec.)
10.0.1.54	3/13/2006	10:13:43	0	3
10.0.1.54	3/13/2006	10:13:46	241	1
10.0.1.54	3/13/2006	10:13:48	413	1
10.0.1.54	3/13/2006	10:13:50	525	2
10.0.1.60	3/13/2006	10:34:12	0	95

These data can be accumulated in two different places, on the user's computer (client side) or on the web server (server side). In this experiment we collected only the server-side data from the WLE and streaming media server. All relevant data for this experiment was collected on the server side because we did not want to be restricted by any browser settings on the client side that might prohibit the actual collection of data.

A log file is usually a simple text file, with one event recorded per entry. A log file can be studied for further cleansing operations and analysis.

A modern LCMS like Blackboard already has some features that allow the recording of log files. With release 6.3 it is now possible to record events in a time frame per content area and per user. The option 'Course Statistics' allows you to record per user which video (submitted in a content area) has been watched and when viewing of this video started. Figure 2.2 demonstrates the number of times one specific video was accessed by all users per hour of the day

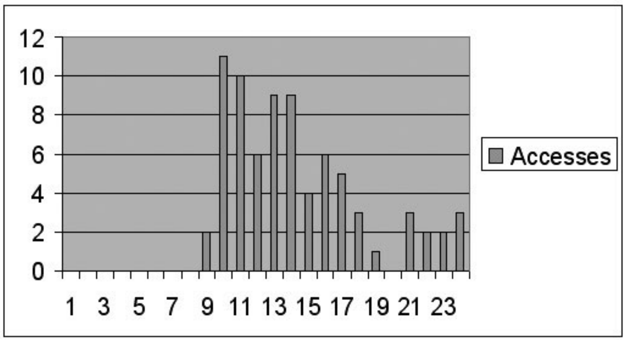

Figure 2.2 Number of accesses per hour of the day

However, the log file does not record the duration of each viewing session. As a result it is still impossible to drill down via viewing scenarios to possible broken links between the lesson task and video.

Table 1 shows a sample log file from a streaming media server, where C-IP is the user's IP address, Date and Time show the elapsed recording time of this event, Starting Point is when the video begins and Duration is the period during which the streaming media server was serving content. The username of the student is not recorded in this log file. In this explorative research we were investigating only possibly interesting patterns in log files so the students were not required to authenticate themselves. There are several entries for the student with IP address 10.0.1.54. Combining these entries indicates something about his viewing scenario.

An interesting integration of both log files (from the WLE server and the streaming media server) is in standard situations almost impossible. This is undesirable because it means useful raw data is lost. For instance, student progress cannot be linked to data in other information systems like student portfolios and progress tracking systems.

In the log files we collected from the streaming media server not all possible item types were stored for further analysis. All the data types in Table 1 were used, including some technical items, to ensure that no local buffering could happen on the client side.

2.3.2 The setting of the experiment

Three groups totalling 50 students from a Groningen polytechnic participated in this experiment. For four weeks they followed a course on designing websites supported by a WLE (based on Blackboard). The students used 12 instruction videos distributed from a streaming media server. These videos on programming in JavaScript were used in the first three weeks to back up the regular lessons. The final assignment had to be handed in by the end of the fourth week. This final assignment was focused on designing a web form, which is used to submit information to a web server. The programming techniques involved are HTML, CSS and JavaScript. In addition, we prepared a schedule for all the intervening subtasks of the final assignment.

The topics of the 12 videos used in this research were aligned with the subtasks of the final assignment. Students were encouraged to begin from day one with programming and designing their web forms, thus strengthening the link with the videos. The following instruction videos were given in Table 2.2.

The quality of the instruction videos produced for this experiment was assessed by the students and we concluded that they were adequate for this experiment.

Table 2.2 All instruction videos with their lengths

Video ID	Instruction video	Length (mm:ss)
V1	Concepts of Forms	6:50
V2	Starting Javascript	13:40
V3	Dreamweaver / Javascript	7:31
V4	FTP / Dreamweaver	9:29
V5	Handling Input from Forms	5:18
V6	Functions	8:44
V7	If and Else	7:17
V8	Document Object Model part 1	5:24
V9	Document Object Model part 2	5:35
V10	Document Object Model part 3	6:29
V11	Forms	8:36
V12	Strings	6:02

2.4 Some results

Before we undertook the explorative analysis of the log file data, we held explorative interviews in a classroom with students exhibiting one or other form of viewing scenario. This was done in order to define more viewing scenarios than the four predicted in theory. Most students used some form of repetitive scenario or two-pass scenario.

The following four scenarios were defined on the basis of the theory presented in section 2 and the results of the student interviews:

2.4.1 Scenario 1

The student watches the video from the beginning to the end in one pass (*one-pass scenario*).
A student begins watching a video. Streaming stops when the video has ended. The server makes an entry of this event in the log file (see Table 2.3).

Table 2.3: Example of a one-pass scenario in a log file from the video V8

C-IP	Date	Time	Starting point (in sec.)	Duration (in sec.)
10.0.2.54	3/20/2006	13:55:44	0	324

2.4.2 Scenario 2

The student stops and replays the video more than once (*repetitive scenario*).
If a student pauses the video after some viewing time – and the server stops streaming – an entry of this event is written to the log file. After a while (during which time the student might be working on the assignment) the student restarts the video streaming from the server. This repetitive scenario results in multiple entries in the log files (see Table 2.4).

Table 2.4 Example of a repetitive scenario in a log file from the video V1

C-IP	Date	Time	Starting point (in sec.)	Duration (in sec.)
10.0.3.54	3/14/2006	13:59:57	0	69
10.0.3.54	3/14/2006	14:01:28	69	41
10.0.3.54	3/14/2006	14:04:02	109	6
10.0.3.54	3/14/2006	14:06:08	114	13
10.0.3.54	3/14/2006	14:06:58	0	5
10.0.3.54	3/14/2006	14:07:01	73	7
10.0.3.54	3/14/2006	14:07:06	88	7

10.0.3.54	3/14/2006	14:07:11	100	3
10.0.3.54	3/14/2006	14:07:14	111	6
10.0.3.54	3/14/2006	14:07:17	123	97
10.0.3.54	3/14/2006	14:09:40	220	49
10.0.3.54	3/14/2006	14:11:04	269	50
10.0.3.54	3/14/2006	14:12:04	319	91

2.4.3 Scenario 3

The student watches the video in two separate sessions (*two-pass scenario*).

Some students watched all the relevant videos in one pass at the beginning of the week and (possibly a few days) later on they watched them again more closely. This results in entries in two separate log files, one for each session (day), and possibly different IP addresses for some students.

The entries to the log file would be a combination of scenarios 1 and 2. A specific example for scenario 3 cannot be given because the students were not required to authenticate themselves.

2.4.4 Scenario 4

The student skips through the video at intervals of relatively short viewing times (*zapping scenario*).
This viewing scenario results in many entries in the log files showing how the students watched only brief fragments of the video (see Table 2.5).

Table 2.5 Example of a zapping scenario in a log file from the video V7

C-IP	Date	Time	Starting point (in sec.)	Duration (in sec.)
10.0.1.14	3/30/2006	7:02:58	0	3
10.0.1.14	3/30/2006	7:03:01	84	2
10.0.1.14	3/30/2006	7:03:04	163	10
10.0.1.14	3/30/2006	7:03:15	257	3
10.0.1.14	3/30/2006	7:03:18	329	6
10.0.1.14	3/30/2006	7:03:24	395	6

All scenarios except one (one-pass scenario) required user interaction. As this interaction can only be recorded in log files on a streaming media server this shows the importance of using streaming video.

After defining these four viewing scenarios we started data mining the log files. After cleansing and pre-processing, however, there was not enough data from the log files from the streaming video server to continue the mining process. The good data available have been used as examples of the four viewing scenarios we have defined.

The mining process was replaced by a questionnaire (N=18). The most important results from this questionnaire are:

Question: When you watched the instruction video, which viewing scenario did you use most?

One-pass scenario: *I watched the video from the beginning to the end in one pass. After watching, I started work on the assignment. There was no need to watch the video again.*	17%
Repetitive Scenario*: I watched the video bit by bit. If I didn't understand something I rewound or fast-forwarded the video and played that bit again.*	61%
Two-pass scenario: *I watched the video twice (or more times). First at the beginning of the week and again later on in the week.*	22%
Zapping scenario: *I did not understand the assignment. I started to zap through the video hoping to find bits that would explain things I could understand.*	0%

We conclude that traces from all four scenarios are present in the data from the log files but not to such an extent that data mining can be performed on these scenarios. The zapping scenario was not scored by students in the questionnaire but there were traces left in the log files indicating that zapping did take place.

2.5 Conclusions

Less than 20% of the students watched the videos in one pass. The vast majority (> 80%) followed lessons by switching between watching the videos and doing the assignments. Tracking this switching – user interaction – involves keeping records and in the case of streaming video this can be accomplished through the log files on the server.

None of the questioned students admitted to zapping. However, a few traces were found in the log files. Perhaps a stronger link between the instruction task and video might prevent zapping behaviour.

According to Blijleven (2005), the cause of the zapping scenario defined in this experiment is based on a broken link between the instruction task and video. Further research should incorporate user authentication in contrast to this experiment where the students were anonymous.

Conducting research in this field involves overcoming technological and didactical issues. The solutions to these issues will fine-tune the streaming media server and ensure that the link between the instruction video and task is not lost.

Future research is necessary. The educational videos will be segmented in a research-based way (Verhagen, 1992; Verhagen, 1993). Authentication of events will enable us to link viewing scenarios to individual attitudes and learning progress. This research will be conducted on a sufficiently larger scale to ensure that data mining can be applied to the log file

Acknowledgements

The authors would like to thank Prof. Dr. E.O. de Brock for his comments on this paper and for his guidance on methodology.

Chapter 3
How to use log files from streaming media servers to determine learning processes[1]

Jelle de Boer

Hanze University of Applied Sciences, Groningen, The Netherlands

***International Journal of Continuing Engineering Education and Life-Long Learning**, 20,* 40-53 (2010)

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[1] The title of this paper changed in the journal to: "*Using log files from streaming media servers for optimising the learning sequence*

Thesis structure:

Chapter:	Main conclusions:
Chapter 1 Introduction Problem statement, research questions, and thesis structure	
Chapter 2 How to interpret viewing scenarios in log files from streaming media servers Research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*	Four viewing scenarios were recognized: one-pass, repetitive, two-pass, and a zapping scenario.
Chapter 3 How to use log files from streaming media servers to determine learning processes Research question: *Can we use log files from streaming media servers to determine learning processes from students, and is there a link with the learning style model from Vermunt?*	Students' learning processes could be monitored through the use of log files. However, we found no clear link between viewing scenarios of students and their learning style.
Chapter 4 Using learning styles and viewing styles in streaming video Research question: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness contribute higher learning outcomes?*	Viewing behavior with streaming video of students is not strongly correlated to short-term memory capacity and learning styles. Students are flexible in changing their viewing behavior. An awareness instruction enhanced their learning outcomes.
Chapter 5 Viewing video for learning Research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*	Students who demonstrate a strategic or a multiple viewing approach attain higher learning effects than students with only one viewing approach. Students with low prior knowledge of the topics are less able to enhance their metacognitive skills. Some students develop marking techniques with the mouse in the media player to watch video more strategically.
Chapter 6 Discussion Findings, implications, reflection, and future work	

In the previous chapter we focused on the following research question: *Which viewing scenarios can be recognized in log files from streaming media servers?* Four viewing scenarios were recognized:

- the *one-pass* scenario, where a student watches a video in one-pass
- the *repetitive* scenario, where a student has to rewind a part of the video which he does not understand
- the *two-pass* scenario, where the student watches the video again after finishing the first time in one-pass
- the *zapping* scenario, where a student skims a video episode in relatively short viewing times.

The viewing behavior of the *zapping* scenario is similar to the learning behavior of a student with an *undirected* learning style from Vermunt (1992). According to Blijleven (2005), a broken link between the learning task and learning process could be the underlying factor of this zapping behavior. Furthermore, if we want to make learning management systems more personalized we might use this learning style of a student. Therefore, learning processes and their possible link with learning styles were investigated further.

The following chapter focuses in the following research question: *Can we use log files from streaming media servers in order to determine learning processes from students and is there a link with the learning style model from Vermunt?*

In the second experiment, as described in the following chapter, the viewing behavior of students was recorded in a controlled environment (usability lab). The log files from streaming media servers were analyzed and semi-structured interviews were held with the students after the learning task.

Abstract

The experiment described in this paper is part of a research project that investigates the possibilities to make learning management systems more adaptive at run-time, based on log files from streaming media servers. In an earlier experiment we defined four viewing scenarios based on anonymous entries in log files from streaming media servers. In this experiment, we investigated whether these log files can tell something about the individual learning processes of students. Students had to perform a learning task from a teacher. Some parts of this learning task required that students watched instruction videos. Clustering the viewing scenarios of a student for the learning task gives a digital trail of the learning process of a student. These trails can be utilised to design learning management systems that are more adaptive at run-time. Moreover, improved learning tasks and improved instruction videos can be designed utilising the information deduced from log files.

3.1 Introduction

This paper is structured as follows. In section 1 (theoretical background) we will discuss in detail the relation between learning processes of students - based on specific combinations of viewing scenarios – and learning tasks from teachers – based on specific combinations of assignments. Furthermore, the relation between viewing scenarios and learning styles will be discussed. Section 2 sets out the design of the experiment in detail. We show the results of this experiment in section 3 and discuss our conclusions in section 4.

The experiment described in this paper is part of a research project and was held in February 2008 at the Hanze University of Applied Sciences, Groningen.. This research project investigates the possibilities to make learning management systems more adaptive at run-time, based on log files of streaming media servers. If LMS's are more adaptive, teachers can make more effective and efficient use of videos and other multimedia objects for students. In an earlier experiment (De Boer & Tolboom, 2008) within this research project, four viewing scenarios were defined based on anonymous entries in log files from streaming media servers. We use the description of these viewing scenarios to describe the trails of an individual student while performing a learning task from a teacher.

We investigated in this experiment whether log files from streaming media servers indeed can tell something about the leaning process of an individual student. To investigate this possibility, we defined a learning task from a teacher. This task consisted of four assignments. Some assignments required watching instruction videos. We compared results from log files with other sources like video's recorded with webcams, eye track data from a usability lab and in-depth interviews with students.

Learning styles and strategies are often proposed as a basis to construct more adaptive learning systems We will also look further into some models of learning styles and their possible link with viewing scenarios based on our earlier research (De Boer & Tolboom, 2008) We will use the learning style model of Vermunt. Reason for this is that in an earlier experiment (De Boer & Tolboom, 2008) zapping in instruction videos was detected in log files. Vermunt's description of an undirected learning style resembles the viewing and zapping behaviour of a student. Also we will look further into the learning style model of Felder & Silverman (1988). Felder links learning styles from students to teaching styles from teachers.

3.2 Theoretical background

In this section we give the theoretical background for this explorative research. Firstly, we will present the research questions for this experiment. Secondly, we will elaborate on the use of digital video and the use of log files from streaming media servers. Thirdly, we will discuss viewing scenarios from students who are watching instruction videos from a streaming media server as part of a learning task from a teacher. Finally, we will discuss the role of viewing scenarios and learning styles in designing adaptive learning systems.

The problem statement for this experiment is that we do not know for sure whether log files from streaming media servers indeed tell something about a student learning process while performing a learning task with videos from a teacher. In an earlier experiment (De Boer & Tolboom, 2008) some patterns called viewing scenarios were defined. However, that experiment was anonymous. Further research was suggested to incorporate user authentication. No conclusions could be drawn about the specific students viewing behaviour in reality. An example of this is a viewing scenario called *one-pass* where student watch the whole video in one time. Log files from such a scenario show that the server has been streaming data to the student for the total length of an instruction video. This does not necessarily imply that students were indeed behind their computer all the time watching the instruction video.

The following research question was formulated: are the viewing scenarios, determined through log files analysis, also describing the learning process of a student? We focus in this experiment on comparing viewing scenarios based on log files with viewing scenarios based on semi-structured interviews to investigate whether there are any differences between them. If there are no differences then we can use log files for real-time adaptive learning management systems. The learning task was defined as a sequence of four assignments with two instruction videos. We defined an intended learning process as a sequence of four viewing scenarios. We used the log files to explore whether there are more learning processes than the intended one.

A new approach proposed in this paper is to link learning task from teachers with so-called intended learning processes, based on a design model for learning environments of Kinkhorst & Zitter (2006) and teacher decision making called Hypothetical Learning Trajectories (Simon, 1995). We use the term learning process to describe all of the students' activities during the learning task. An intended learning process occurs when a student follows a path defined by the teacher. All other routes are called unintended learning processes. An adaptive learning management system should be able to adapt for both types of learning processes because not all unintended learning processes are inappropriate.

Just as in e-business, in education web and streaming media server log files can be used for personalization and evaluation. In educational settings, however, the use of log files for data mining is not employed to any large extent (Hewitt et al., 2003). Log files are used mostly for detecting errors in the infrastructure and get thrown away immediately afterwards because they reduce overall system performance. In this experiment we collected the server-side data from the streaming media server which distributed the instruction videos to the student.

Log files alone are not enough to interpret data. The context of use should also be incorporated. Log file analyses can only be interpreted reasonably well when additional data concerning the context of use is available (Pape et al., 2005). In the experiment of this research, we used eye tracking data and a webcam from a usability lab to interpret that students were indeed performing the learning task at hand. Furthermore, we held semi-structured interviews right after the learning task. So there were two extra data sources available to check if there were any differences between the data from the log files and the data from the semi-structured interviews.

Online streaming video servers are a recent technological development in the distribution of video. Recent research has shown that streaming videos can be used fruitfully in education, provided technical problems are overcome and the content is embedded in the curriculum in general and specifically in assignments (Hanna, 2000), (Gibbs et al., 2001), (Green et al., 2003), (So & Pun, 2002), (Boster et al., 2006), and (Fill & Ottewill, 2006).

The learning task used in this experiment consists of watching two instruction videos and performing two assignments based on those instruction videos. The function of such a video component is threefold (Van den Berg & Visscher-Voerman, 2000). First of all, video has the function to demonstrate. Software tools in education for instance can be demonstrated in this way through screen capturing some parts of their functionality. Secondly, video has the function to inspire. By providing an example of innovative education to students, teachers inspire students to experiment with these examples in their own educational work and in so doing contribute to their competences. The third function is to stimulate reflection and critical analysis of the professional working methods. The instruction videos used in this experiment belong to the first category.

Each interaction from a student with the instruction video (starting, pausing, etc) results in a separate entry in the log file from the streaming media server. Specific combinations of these entries from one student in log files can be addressed as a viewing scenario. De Boer and Tolboom (2008) conducted an experiment where they studied viewing scenarios from students who were watching instruction videos. They defined four viewing scenarios: *one-pass, two-pass, repetitive* and *zapping scenarios*. If a student watches a video in one pass from the beginning to the end, they called this viewing pattern a *one-pass scenario*. If a student watches a video or parts of a video repeatedly, they called this viewing pattern a *repetitive scenario*. Sometimes, students seem to skip through the instruction video at regular intervals of relatively short viewing times. They called this viewing pattern a *zapping scenario*. If a student watches a video again after a few days, they call this a *two-pass scenario*. The learning task in this experiment is completed in approximately 45 minutes so the two-pass viewing scenario is not relevant for this experiment.

Learning styles and strategies are often proposed as a basis to construct more adaptive learning systems. Michael Abell for instance describes a model (Abell, 2006) guided by learning styles and emerging digital media to individualize learning with the help of intelligent agents. Furthermore, one of the viewing scenarios defined is zapping. According to Blijleven (2005) a broken link between the learning process and the leaning task at hand could be the reason for this. We investigate if there is any connection with learning styles to account for such clicking behaviour.

There are many learning styles and also many learning style instruments, described in a survey of the Learning & Skills Research Centre (Livingston, 2004) In that survey one of the valid instruments and models is the one developed by Vermunt (1992). Vermunt not only speaks of learning styles and strategies from a cognitive viewpoint but also from a self-regulating and motivation viewpoint. Vermunt argues that four qualitatively different learning styles can be discerned: an *undirected*, a *reproduction directed*, a *meaning directed* and an *application directed* learning style. Mental models of learning and learning orientations turn out to be related to the way in which students interpret, appraise and use instructional measures to regulate their learning activities. There are large differences among students in the manner in which they carry out learning functions. These differences are associated with internal and external sources. Furthermore, the preferred learning style can be scored with an online index of learning styles test (ILS). Interesting question is whether there is a correlation between learning styles and viewing scenarios. For instance: does a student who is zapping through instruction videos also have a preference for an undirected learning style? The model of Vermunt has been used in this experiment.

Another model of learning styles is the one of Felder & Silverman (1988). He introduces 32 learning styles in his framework based on five dimensions: *perception, input, organization, processing,* and *understanding*. Furthermore, he introduces five teaching styles to accommodate these learning styles also based on five dimensions: *content, presentation, organization, student participation* and *perspective*. This model is used in this experiment to understand one of the outcomes of the interviews. It tells us that video is not always the preferred input for students.

Felder also advocates addressing all possible learning styles in a classroom with all possible teaching styles to some extent. We propose to use a more adaptive form of teaching compared to Felder and also the use of adaptive learning management systems (De Bra et al., 1999). De Bra describes Adaptive Hypermedia Systems (AHS) that make it possible to deliver "personalized" views or versions of a hypermedia document without requiring any kind of programming by the author(s). Also, although it is possible to offer users a way to initialize the user model through a questionnaire, an AHS can do all the adaptation automatically, simply by observing the browsing behaviour of the user. Bures (2006) describes that automatic generation of such a user model can improve data consistency and stability of adaptive e-learning hypermedia systems.

A more adaptive and conceptual framework is also proposed by Abell (2006). This framework harnesses the potential of intelligent learning systems, machine learning models, and universal design for learning principles to help formulate next generation instructional materials. By using intelligent and interactive curricula, educators could begin to move away from information disseminator into a facilitator of the learning experience.

Promising results for using an adaptive environment are presented by Kommers et. al (2008). Their study compares the effectiveness of two performance support systems, adaptive and non-adaptive, on learning achievements of engineering students. In addition, the research design controls for a possible effect of learning style. The analysis reveals that students working with an adaptive performance support system score significantly higher than students using a non-adaptive performance system on a performance test across different learning styles.

The learning task at hand is situated at the beginning of the course about XML and consisted of a 45-minute introduction lesson about XML with two instruction videos and two assignments. First the students watch the instruction video about XML. After the first instruction video, they have to perform an accompanying assignment about XML. They can use the same instruction video about XML again if needed. The last two parts are similar to the first two parts except for the topic in the instruction video (DTD instead of XML). The learning processes in this experiment consist of a combination of four viewing scenarios, linked to the four parts of the learning task. Using IMS [http://www.imsglobal.org] notation, this is shown at the left of Figure 1. The intended learning process for this learning task from the teacher is that a student first watches the instruction video in a *one-pass scenario* and – in order to make the assignments– is subsequently watching specific parts of that instruction video in a *repetitive scenario*. The complete intended learning process is: *one-pass, repetitive, one-pass,* and *repetitive*.

The link between the learning task and the learning process is visualized by the arrows in Figure 1. A broken link due to not completing an assignment is represented by the absence of one or more viewing scenarios in Figure 3.1. Another example of a broken link is that students zap through instruction videos. According to Blijleven this can occur if there is a broken link between the learning task and the instruction video. This broken link is visualized by the presence of one or more zapping scenarios in the learning process. Vermunt's description of the undirected learning style (Vermunt, 1992) could be the reason for this zapping behaviour.

At the student level, we see a diversification of learning processes. However, at the teacher's level we see a convergence of a learning task. Solution for the student, within the context of this research, is personalisation of the learning management system. If an LMS can adapt for many learning processes, students can eventually study more efficient and effective.

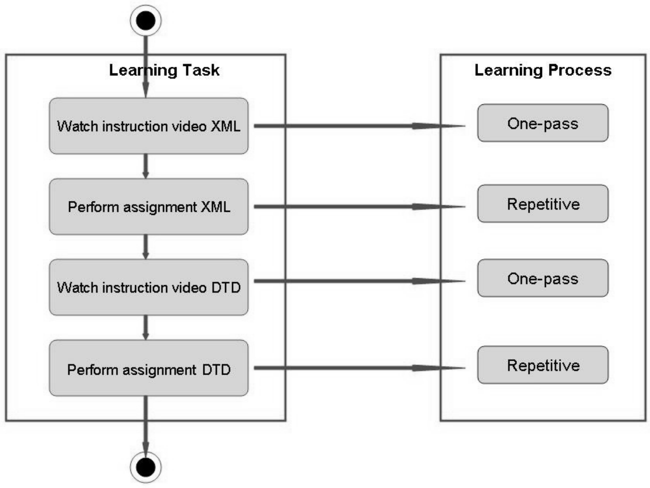

Figure 3.1 Learning task from a teacher and the corresponding intended learning process of a student (see online version for colours)

3.3 Design of experiment

In this section, we will elaborate the design of the experiment. Firstly, we will describe the student population and the learning task including instruction videos involved. Secondly, we will describe the recording of the learning process using webcams and eye tracking in a usability lab. Finally, we describe the data collected: log files from the streaming media server, the preferred learning style of a student using an online questionnaire, and semi-structured interviews held right after finishing the learning task.

A group of 23 undergraduate students at the Hanze University of Applied Sciences, Groningen individually performed a learning task in this experiment as the first lesson of a course in the eXtensible Markup Language (XML). This course is part of second year program of the major Communication Systems. The learning task - a 45-minute introduction lesson about XML - consists of two instruction videos and two assignments. We instructed the students at the start of the learning task they should finish the lesson in about 45 to 60 minutes. The teaching model used was as follows: first the students watch the instruction video about XML (with a length of 8.39 minutes). After the first instruction video, they have to perform an accompanying assignment about XML. They can use the same instruction video about XML again if needed. The last two parts are similar to the first two parts except for the topic in the instruction video (DTD instead of XML). The length of the second instruction video used was 6.54 minutes.

Log files alone are not enough to analyze the learning process. To conclude that a student indeed has been watching a video, more data sources have to be collected. The learning task was not performed in a regular lesson but individually in a usability lab. A usability lab is an environment where users are studied interacting with a software system or interface for the sake of evaluating the system's usability. In other words, a usability lab is a place where usability testing is done. To evaluate the usability of a system one can record the movements of the eyes and one can record with a webcam the student and its surroundings. Students were scheduled for one hour to visit the usability lab and to perform the learning task. Four media sources were recorded: screen capture of the learning task, eye tracking data in terms of fixation points and lines between these points, webcam, and audio from a microphone.

While performing the learning task, students were watching instruction videos distributed from a streaming media server. Table 1 shows a sample log file from a streaming media server, where *C-IP* is the user's IP address, *Date* and *Time* is the time when the streaming event starts, *Starting Point* is the starting position in the instruction video where streaming begins and *Duration* is the period during which the streaming media server was watched. The username of the student is not recorded in this log file but in another log file from the media server and from the planning schedule for this experiment. There are several entries for the student with IP address 10.0.1.54. Combining these entries indicates something about his viewing behaviour. Table 3.1 is an example of a possible zapping scenario: short viewing times in each entry.

Table 3.1 Log file data from a streaming media server (zapping scenario)

C-IP	*Date*	*Time*	*Starting point (in sec.)*	*Duration (in sec.)*
10.0.1.54	3/13/2006	10:13:43	0	3
10.0.1.54	3/13/2006	10:13:46	241	1
10.0.1.54	3/13/2006	10:13:48	413	1
10.0.1.54	3/13/2006	10:13:50	525	2

Semi-structured interviews were held right after the learning task. Four topics were discussed. Firstly, we asked if something unusual had happened during the learning task which could influence the results. Secondly, we asked about the quality of the instruction video. Thirdly, we asked them – after instructing them about the four viewing scenarios – to score their learning process in terms of these viewing scenarios. Finally, students were asked to fill in an online questionnaire to score their preferred learning style. This online questionnaire is based on the model of Vermunt.

3.4 Results

In this section we will discuss the results from this experiment. Firstly, we will discuss the differences between the measured viewing scenarios from the students, based on log files and semi-structured interviews. Secondly, we will describe the learning processes of students apart from the intended one. Thirdly, we will discuss the link between learning processes and learning styles. Finally, we introduce an extra viewing scenario based on eye tracking a more appropriate name for viewing scenarios.

In Table 3.2, viewing scenarios of one student are scored in the last column for the first two parts of the learning task (watch video XML and perform assignment XML). The length of the instruction video was 519 seconds.

Table 3.2 Viewing scenarios for the XML-part of the learning task

IP address	*Date (mm/dd/yyyy)*	*Time (hh:mm:ss)*	*Start time in video (sec.)*	*Duration (sec)*	*Viewing scenario*
10.0.1.248	2/12/2008	12:47:03	0	519	One-pass
10.0.1.248	2/12/2008	13:00:30	0	20	
10.0.1.248	2/12/2008	13:00:46	22	12	
10.0.1.248	2/12/2008	13:00:56	28	3	
10.0.1.248	2/12/2008	13:02:07	30	21	
10.0.1.248	2/12/2008	13:02:46	50	6	
10.0.1.248	2/12/2008	13:02:50	74	4	
10.0.1.248	2/12/2008	13:02:52	96	26	Repetitive
10.0.1.248	2/12/2008	13:06:23	121	3	
10.0.1.248	2/12/2008	13:06:24	132	5	
10.0.1.248	2/12/2008	13:06:27	162	4	
10.0.1.248	2/12/2008	13:06:29	182	3	
10.0.1.248	2/12/2008	13:06:31	207	4	

The last two parts about DTD showed comparable results and are not shown in Table 3.2 because they do not provide extra information. Hence, the measured learning process of this student was: *one-pass, repetitive, one-pass, repetitive*. This is also the intended learning process of the teacher.

The viewing scenarios and learning processes of all 23 students are summarized in Table 3.3. In the first column is the student's number. The second column is split into four sub-columns with the measured viewing scenario based on log files. The four viewing scenarios together form the learning process. The third column shows viewing scenarios and learning processes based on semi-structured interviews. No score of a viewing scenario occurs when a student is making the assignment without watching an instruction video.

Scores of the measured learning processes mutually differ only for two students (nr. 4 and nr. 22). For 21 students the learning process defined in terms of a sequence of four viewing scenarios based on log files, is the same as the viewing scenarios based on semi-structured interviews. So, measuring learning processes in terms of viewing scenarios based only on log files would have been representative for this experiment.

For 18 students the measured learning process is also the intended learning process (O-R-O-R), scored with log files and interviews. Two students (nr. 8 and nr. 10) however did not need to watch the instruction movies again to complete the assignments. Another student (nr. 18) began the assignment without finishing the instruction video. We can also consider these two learning processes as an appropriate learning process: not all students need to watch the instruction videos completely or for a second time. We also confirmed with the video data from web-cams and eye tracking to confirm that the learning process described by students was indeed what they answered in the semi-structured interviews.

The learning styles of the students are summarized in Table 3.4. In the first column is the student's number. Fourteen of the 23 students scored their learning style using the online index of learning styles (ILS) test. Nine of the scored learning styles are empty. This is due to the sudden disappearance of these students who went studying abroad. Despite many efforts they did not return their scores. Nine of these fourteen students scored one of the three preferred learning styles of Vermunt and five students scored the undirected learning style. One of the students (nr. 6) showed traces of zapping in the log files but not to a large extent.

Table 3.3 Measured learning processes (combination of four viewing scenarios), scored from log files and interviews

N	*Learning process (from log files)*				*Learning process (from interviews)*			
	1	2	3	4	1	2	3	4
1	O	R	O	R	O	R	O	R
2	O	R	O	R	O	R	O	R
3	O	R	O	R	O	R	O	R
4	R	R	R	R	O		O	
5	O	R	O	R	O	R	O	R
6	O	R	O	R	O	R	O	R
7	O	R	O	R	O	R	O	R
8	O		O	R	O		O	R
9	O	R	O	R	O	R	O	R
10	O	R	O	R	O	R	O	R
11	O		O		O		O	
12	O	R	O	R	O	R	O	R
13	O	R	O	R	O	R	O	R
14	O	R	O	R	O	R	O	R
15	O	R	O	R	O	R	O	R
16	O	R	O	R	O	R	O	R
17	O	R	O	R	O	R	O	R
18	R	R	R	R	R	R	R	R
19	O	R	O	R	O	R	O	R
20	O	R	O	R	O	R	O	R
21	O	R	O	R	O	R	O	R
22	*R*	*R*	*R*	*R*	*O*		*O*	*R*
23	O	R	O	R	O	R	O	R

Notes: (O = one-pass scenario, R = repetitive scenario)

However, in the interviews the five students with an undirected learning style did not score themselves as zapping. This can possibly be explained by the fact that the topics covered are at an introduction level. Verhagen (1993) conducted a pre-post-retention study to gather further insight in the relationship between (self-chosen and program-controlled) segment length of an interactive videodisk program and performance on post- and retention tests. Segment length is not only related to the time length of the video fragment but also related to the amount of information presented. The longer the video segments were, the lower, on average, was the recall of factual information. Furthermore, the ILS test showed the undirected learning style was scored just slightly higher than one of the preferred learning styles.

Table 3.4 Preferred learning style of the students (Vermunt)

N	*Learning style (Vermunt)*	*N*	*Learning style (Vermunt)*
		12	
1	Meaning	13	Application
2		14	Undirected
3	Meaning	15	Undirected
4	Meaning	16	Undirected
5	Application	17	Undirected
6	Undirected	18	
7	Application	19	
8	Application	20	
9	Meaning	21	Application
10		22	
11		23	

The quality of the instruction videos used in this experiment was more than adequate according to all 23 students. All students scored the technical quality (resolution, sound, etc) and the contents of the video on a scale of 1-10 between 7 and 8.

Two students (nr. 11 and nr. 15) preferred text-based tutorials rather than video-based material. This confirms the findings of Felder & Silverman (1988), stating that watching video is not always a preferred teaching style component for students. Furthermore, one student had a mild form of ADHD but did not score an unintended learning process in this introduction lesson.

We propose to extend the series of four viewing scenarios with a fifth one called *snorkelling scenario*. After analyzing the eye tracking data, we noticed that students were looking for specific parts in the instruction videos, resulting in another type of viewing scenario than the most appropriate one (the repetitive scenario). They were pausing the instruction video on specific parts of the instruction video in order to make the assignment. They did not remember the XML knowledge presented in the instruction video. This searching pattern resembles snorkelling of a diver when searching for an object: start with searching at the surface and when the object is found dive deep.

We also propose the term *viewing style* instead of *viewing scenario*. Viewing scenarios is a description of a sequence of events and with no personalisation element of a student. Viewing style, when compared to *learning style*, accounts more appropriate for the personal element involved.

3.5 Conclusions and discussion

In this section we will present the conclusions based on the results of the experiment. Also, we will discuss these results.

Results show that for 21 of the 23 students the learning processes, defined in terms of a sequence of viewing scenarios, based on log files are the same as the ones based on semi-structured interviews. So, conclusion is that measuring learning processes in terms of viewing scenarios based only on log files would have been representative for this experiment.

Most students (18 of the 23) exhibited the intended learning process. The rest (5 of the 23) of the students showed a diversification of learning processes. However, three of these five students showed an appropriate but yet unintended learning process: they started making the assignment before finishing the instruction video. Adaptive learning systems should be able to take this into account. They have to respond preferably automatic and in real-time to this user-specific information.

Only one of the five students, who scored the undirected learning style, showed traces of zapping in the log files but not to a large extent. However, in the interviews these five students did not score themselves as zapping. This can possibly be explained by the fact that the ILS test showed the undirected learning style was scored just slightly higher than one of the preferred learning styles. Furthermore, the topics covered are at an introduction level. Verhagen shows that segment length is also a possible relevant factor. Further studies should incorporate longer videos with more information elements to possibly reveal zapping behaviour.

Two students preferred text-based tutorials rather than video-based material. This confirms the findings of Felder & Silverman (1988) stating that watching video is not always a preferred teaching style component for students. This should be used in adaptive learning management systems, for instance in a user model of an AHS.

We proposed to extend the series of four viewing scenarios with a fifth one called *snorkelling scenario*. Students were looking for specific parts of the instruction videos, resulting in another type of viewing scenario than the most appropriate one called repetitive scenario. This searching resembles snorkelling of a diver. Also, we propose to use the term *viewing styl*e instead of *viewing scenario*. This accounts more for the individual learning aspect of a student instead of focussing on a sequence of events.

Using log files to describe learning processes as a combination of viewing scenarios seems promising. Firstly, we do not always have to interview students to measure their learning process. Furthermore, we can anticipate in real-time on their expected clicking behaviour by using this information in adaptive learning environments.

Further research is necessary to make intelligent agents, not only based on log files from standard information systems but also from streaming media servers. Also, adaptive learning systems for students should be designed which use this information directly. Finally, improved learning tasks and instruction videos can be the result of the information deduced from log files.

Acknowledgements

The author would like to thank Prof. Dr. E.O. de Brock, Dr P.A.M. Kommers and Drs. J.H.L. Tolboom for their feedback on earlier versions of this paper.

Chapter 4
Using learning styles and viewing styles in streaming video

Jelle de Boer [a*], Piet A.M. Kommers [b] and Bert de Brock [c]

[a] Institute of Communication & Media, Hanze University of Applied Sciences, Zernikeplein 7, 9747 AS, Groningen, The Netherlands

[b] Faculty of Behavioural Sciences ,University of Twente, P.O. Box 217, 7500 AE, Enschede, The Netherlands

c Faculty of Economics and Business ,University of Groningen, P.O. Box 800, 9700 AV, Groningen, The Netherlands

Computers & Education*, 56,* 727-735 (2011)

Thesis structure:

Chapter:	**Main conclusions:**
Chapter 1 Introduction Problem statement, research questions, and thesis structure	
Chapter 2 How to interpret viewing scenarios in log files from streaming media servers Research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*	Four viewing scenarios were recognized: one-pass, repetitive, two-pass, and a zapping scenario.
Chapter 3 How to use log files from streaming media servers to determine learning processes Research question: *Can we use log files from streaming media servers to determine learning processes from students, and is there a link with the learning style model from Vermunt?*	Students' learning processes could be monitored through the use of log files. However, we found no clear link between viewing scenarios of students and their learning style.
Chapter 4 Using learning styles and viewing styles in streaming video Research question: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness contribute higher learning outcomes?*	Viewing behavior with streaming video of students is not strongly correlated to short-term memory capacity and learning styles. Students are flexible in changing their viewing behavior. An awareness instruction enhanced their learning outcomes.
Chapter 5 Viewing video for learning Research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*	Students who demonstrate a strategic or a multiple viewing approach attain higher learning effects than students with only one viewing approach. Students with low prior knowledge of the topics are less able to enhance their metacognitive skills. Some students develop marking techniques with the mouse in the media player to watch video more strategically.
Chapter 6 Discussion Findings, implications, reflection, and future work	

In the previous chapter we focused on the following research question: *Can we use log files from streaming media servers in order to determine learning processes from students and is there a link with the learning style model from Vermunt?*
It demonstrated that students' learning processes could be monitored through the use of log files. However, there was no clear link between viewing scenarios of students and their underlying learning style. Vermunt's distinction of learning styles not only includes a cognitive- but also a self-regulating and a motivational perspective. Therefore, our focus changed from learning styles to more pervasive personality traits like cognitive styles and the short-term memory of students.

This brought us to the third experiment which will be described in the following chapter. The third experiment consists of two parts. The first part focused on the cognitive perspective and investigates whether the students' viewing behavior is determined by pervasive personality traits. The second part focused on the awareness about viewing styles.
We focused on the following two research questions:
-Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory?
-Can viewing style awareness contribute to higher learning outcomes?

The students' viewing behaviors were investigated in a controlled environment (usability lab). Semi-structured interviews were taken from the students after they performed the learning task.

Abstract

Improving the effectiveness of learning when students observe video lectures becomes urgent with the rising advent of (web-based) video materials. Vital questions are how students differ in their learning preferences and what patterns in viewing video can be detected in log files.

Our experiments inventory students' viewing patterns while watching instructional videos. Four viewing styles were postulated and checked for correlations with existing learning styles and the recent signaling of parallels with the learner's short-term memory capacity. Finally we checked whether learners' awareness of their actual viewing style potentially contributed to learning outcomes.

The viewing behavior of 51 undergraduate students has been investigated. The students performed an individual learning task based upon instructional videos. Felders learning styles test and Huai's short-term memory test were used and checked for correlation. Video recordings in a usability lab were used to measure the students' viewing behavior. A multiple-choice test was integrated to measure possible learning effects. Moreover, students were interviewed afterwards.

No strong correlation between the viewing styles and pervasive personal traits of students was perceived. Some students seem to switch their viewing style based upon their cognitive need, without lowering their test score. This flexibility of the student in adapting his viewing behavior might account for the missing correlation between pervasive personality traits and viewing styles. Students scored 20% higher on the test scores when using an awareness instruction.

4.1 Introduction

The challenge to improve the effectiveness of learning by using video lessons has become urgent as web-based materials contain more and more video and control tools for the learner. Earlier research into the ideal length of video fragments was based upon interactive video such as those via video discs when the zapping user was an unknown phenomenon. The web has created a much more autonomous and flexible student attitude. If we want to improve any aspect of students' learning from video, it is inevitable to typify and understand how they differ in their learning preferences (Yang & Tsai, 2008). The question arises what patterns in viewing video can be detected in logging files.

The experiment described in this paper is the third stage of a research project that investigates the possibilities to make learning management systems adaptive based upon log files from streaming media servers. In the first experiment (De Boer & Tolboom, 2008) four viewing scenarios based on anonymous entries in log files from streaming media servers were defined.

In the second experiment (De Boer, 2010), the log files were inspected for meaningful indications on how to adapt further to the individual leaning processes of students. In this third experiment, the viewing behavior of students was linked to pervasive personality traits like their learning style and the capacity of students' short-term memory.

Video is being used increasingly as an instructional tool in education and therefore it becomes important to optimize the learning process of students from video lessons. Furthermore, students are instructed to enhance their learning skills to from text but not from video. Finally, interacting with the control buttons of a media player gives students only standard tools to interact (start and stop) with video hardly supporting the learning process.

Streaming video servers are frequently used to distribute video to students nowadays. These servers are logging event queues: (pausing, rewinding, etc) in so called log files. Just as in e-business, log files can be used for personalization and evaluation. In educational settings, however, the use of log files for mining purposes has not yet been employed to a large extent (Hewitt et al., 2003). Log files are mostly used for detecting errors in the infrastructure and will be deleted as they may reduce overall system performance. Shih, Feng, & Tsai (2008) have observed a clear trend that more and more studies were utilizing learner's log files as data sources for analysis.

However, it seems worth investigating in order to find out the best way to chunk video streams into meaningful segments for the sake of optimizing study results. If the viewing behavior of a student potentially influences his or her learning outcomes, we can also use these loggings for delivering individual feedback to the student. More adaptive and more effective learning management systems may be applied the coming years.

The rest of this paper is organized as follows. In Section 2, the literature review is focused on the use of streaming video and the collection of log files. In Section 3, the background of learning styles and short-term memory is presented. In Section 4, the use of some adaptive systems is given. In Section 5, the research setup of the experiment is presented. In Section 6, experimental results are presented. Finally, the discussion is given in Section 7.

4.2 Relevant work

Our earlier research will be presented in this section, together with relevant work, and the research question.

The experiment in this paper is part of a research project. The experiments in this project investigate the possibilities to make learning management systems more adaptive at run-time, based on log files from streaming media servers. In the first experiment (De Boer & Tolboom, 2008), four viewing scenarios were defined based on anonymous entries in log files from streaming media servers. One of those scenarios was 'viewing by zapping' where a student seems to zap through a video episode. According to earlier research (Blijleven, 2005), a broken link between the learning task and the learning process could be the cause of this. Also, the zapping viewing scenario shows patterns of the 'undirected' learning style as distinguished by Vermunt (1992).

In the second experiment (De Boer, 2010), learning processes and learning styles were investigated further. It demonstrated that students' learning processes (constituting a learning task) could be monitored through the use of log files. However, there was no clear link between viewing scenarios of students and their learning style. Vermunts learning style model includes not only a cognitive perspective but also a self-regulating and motivation perspective.

The third experiment addresses the main topic of this paper and focuses on the cognitive perspective and investigates whether the students' viewing behavior is determined by pervasive personality traits. The question is how this understanding can be used in order to optimize student results. The theoretical underpinning has been based upon earlier work by Huai (2000), who found a correlation between the learning style and the short-term memory of a student. Learners with a weaker short-term memory need to derive lost elements in short term memory by actively recruiting and elaborating elements from long-term memory. Learners with a holistic style build a much more integrated knowledge structure that pays back in terms of flexible problem solving and a much larger factual repertoire in the long run.

The question for the experiment is if and how the linear and holistic learning style can been detected in students' viewing behavior while learning from video segments. The research question was formulated as: *Does a student's viewing behavior correlate with more pervasive personality traits such as short-term memory capacity?*

The interaction moments of a student was explored in the context of his navigation while learning from video segments. Navigation is carried out with the control buttons of the media player and may have several purposes. For instance, students may pause a video in order to explore a complicated still frame with a high information density. Students can also return to a specific segment of the video or the complete video. Interacting with the control buttons of the currently standard Windows Media Player allows the student only basic tools to interact with the video resources.

Optimizing the order of video segments in terms of meaningful episodes is therefore of prime importance. Ausubel (1960) primed the idea of “advance organizer”. It implies that meaningful learning can be provoked by initiating the semantic conceptual skeleton before subsuming its subordinate details.

Verhagen (1992) investigated the optimum video segment length in the early nineties. He defined the maximum number of questions as the total amount of information elements. He distinguished some typical information elements and roles in the segment lengths chosen by a group of students. His goal was to formulate design rules for learning from video material. The outcome showed that students often halted when a video segment seemed to be finished, e.g. the change of the camera angle.

Each interaction with the control buttons of the media player results in a separate entry in a log file from the streaming media server. Specific combinations of these entries from one student in log files can be conceived as a “viewing scenario”. De Boer et al. (2008) observed students' viewing scenarios while watching instructional videos. The logged interaction events have in common that students prefer to escape from the default viewing sequence for a variety of reasons. For instance, the student may want to improve his understanding of a specific segment before continuing with the next segment or he want to memorize the contents. These interactions will be labeled as *stopping moments* further on.

Four entries and five attributes in a log file from a streaming media server are shown in Table 4.1.

- *IP-address* is the user's IP address.
- *Date* and *Time* is the time when the streaming event starts.
- *Starting Point* is the starting position in the instructional video where streaming begins.
- *Duration* is the period of watching the streamed media.

There are several entries for the student with a certain IP address. Combining these entries allows the researcher to typify the pattern in viewing behavior of a specific student. Table 4.1 shows a typical zapping scenario: short viewing times (*duration*) in each entry.

Table 4.1
Log file data from a streaming media server (zapping scenario)

IP-address	Date(m:dd:yyyy)	Time(hh:mm:ss)	Starting point (in sec.)	Duration (in sec.)
10.0.1.54	3/13/2006	10:13:43	0	3
10.0.1.54	3/13/2006	10:13:46	241	1
10.0.1.54	3/13/2006	10:13:48	413	1
10.0.1.54	3/13/2006	10:13:50	525	2

De Boer et al. (2008) defined four viewing scenarios: *one-pass, two-pass, repetitive* and *zapping scenarios*. Table 4.2 describes the viewing behavior of these four viewing scenarios.

Table 4.2
Viewing scenarios, viewing behavior, and viewing styles

Viewing scenario	Viewing behavior	Viewing style
One-pass Scenario	a student watches a video in one pass (uninterruptedly) from the beginning to the end	Linear
Two-pass Scenario	a student watches a video again after finishing the first time in one-pass	Elaboration
Repetitive Scenario	a student watches parts of a video repeatedly	Maintenance Rehearsal
Zapping Scenario	a student skips through the instructional video at intervals of relatively short viewing times	Zapping

The student's choice among the four viewing scenarios in this first experiment was not determined by the will to achieve a high test score because there were no tests in the learning task. Combinations of several viewing scenarios were investigated in the second experiment (De Boer, 2010). In this third experiment however, a test will be used in a controlled situation and therefore we will not investigate the zapping scenario further.

4.3 Viewing patterns and learning styles

In this section, the underpinning theory about learning styles and short-term memory will be discussed in relation with viewing patterns.

Learning styles and learning strategies are used quite often in the same way in research. Kirby (1984) made a distinction between styles and strategies: style is a stable way of approaching tasks while strategies are ways of handling particular tasks. Two relevant strategies of Craik & Lockhart (1972) for this research are *maintenance rehearsal* versus *elaboration*. Maintenance rehearsal is the strengthening of elements in the short-term memory through repetition. Elaboration is the meaning-oriented rehearsal using related knowledge from long-term memory.

The elaboration learning strategy from Craik & Lockhart is similar to the two-pass viewing scenario (recruiting semantically-related knowledge from one's long-term memory), often labeled as a process of meaningful elaboration. Its role is to establish connections among prior and new concepts in the student's mind. In terms of cognitive style we may distinguish elaboration versus maintenance as two complementary trends to memorize. In terms of study approach we may recognize elaboration as a way to prioritize the process of understanding rather than merely memorization. The maintenance rehearsal approach learning strategy is similar to the repetitive viewing scenario through the refreshing of memory. A viewing scenario based upon rehearsal implies that a student needs support based on the chronological order of the video segments. Therefore it is a kind of maintenance rehearsal and also rote learning (learning by repetition).

Following Craik & Lockhart and De Boer (2010), who suggested to use the term *viewing style*, we introduce the next terms for the viewing behavior of students: *elaboration viewing style* , *maintenance-rehearsal viewing style*, and *linear viewing style*. In Table 4.2 we list these viewing styles including the zapping style from our earlier experiments.

Our research question focuses on a correlation between the viewing behavior of a student and pervasive personality traits like learning style and short-term memory, based on earlier work of Huai (2000). She signaled a parallel between the students' learning style and his/her short-term memory capacity. Huai studied the descriptions of learning styles and cognitive styles for the design of her short-term memory test which we also used in our experiment. Cognitive styles are related to the organization and control of cognitive processes and learning styles to the organization and control of strategies for learning and knowledge acquisition (Messick, 1987). Learning styles can be considered as a stable way of approaching learning tasks that are characteristic of individuals (Biggs, 1988). Huai defined four learning styles on the dimension holistic versus serialistic: holists, serialists, versatiles and the unknown-style. Serialists adopt a sequential learning approach and concentrate on details and procedures. Holists adopt a global, thematic approach to learning. Versatile students may adopt both approaches. Students with "unknown-styles" do not display ingredients of learning styles anyway.

Huai also explored the relation between short-term memory and learning styles. Short-term memory, according to (Ashcraft, 1989) is a working memory system where the information is held for further mental processing. It can hold a variety of informational codes, acoustical information, etc. Its capacity is limited. Miller (1956)

suggested that short-term memory span is seven plus or minus two chunks. A chunk is a cluster of items. The functional duration of short-term memory is about 15 to 20 seconds and fades away without maintenance or elaboration rehearsal. Huai showed that holists have a lower capacity of short-term memory and serialists a higher short-term memory capacity.
Students, who score low on a short-term memory test, are expected to pause or rewind the videos at an earlier moment compared to students who score high on this test. We included this understanding in our experiment whether or not styles are related to the students' short-term memory and their subsequent learning style in terms of holistic/serialistic sequencing approach.

Huai used the Smugglers Test in her experiment to score the learning style (serialist – holist) which is time consuming and therefore of little use in online learning environments. Graf, Lin, & Kinshuk (2008) indicate that we can use the score on the dimension *understanding* (serialist - global) to measure the serialist - holist learning style when using the ILS test of Felder & Silverman (1988). Felder & Silverman introduced 32 learning styles embedded in five dimensions: *perception, input, organization, processing,* and *understanding*. They further introduced five teaching styles in order to accommodate these learning styles also based on five dimensions: *content, presentation, organization, student participation* and *perspective*. Felder & Silverman advocate addressing all possible learning styles in a classroom with all possible teaching styles to some extent. They developed an online Inventory of Learning Styles. This online test measures four of the five dimensions with eleven questions per dimension. All 44 questions were scored, but only the 11 questions on the dimension *understanding* (sequential – global) were used.

4.4 Adaptation

In this section some uses of adaptive systems and the operational research questions will be discussed.

Learning style and learning strategies are often proposed as a basis for constructing more adaptive learning systems. Abell (2006) has described a model guided by learning styles and emerging digital media to individualize learning with the help of intelligent agents. Tseng, Chu, Hwang, & Tsai (2008) have proposed an innovative adaptive learning approach based upon two main sources of personalization, that is, learning behavior and personal learning style.

Schiaffino, Garcia, & Amandi (2008) identify two main research directions: adaptive educational systems and intelligent tutor systems. The latter ones are characterized by its continuous efforts to optimize both the system responsiveness and the learners' meta-cognitive awareness. Instead of the opportunism to adapt the medium to the latent learner traits, it provokes the learner to become more active and cope with his/her unbalanced mental trend or even mental repertoire. Adaptive educational systems accommodate the variety in the presentation of content and navigation through the student’s profile. Intelligent tutor systems recommend educational activities and deliver individual feedback according to the student’s profile. Schiaffino, Garcia, & Amandi proposed an agent (eTeacher) that can be considered as an intelligent tutor who unobtrusively observes the student’s behavior and builds the profile.

In order to detect a student’s learning style, Garcia, Schiaffino, & Amandi (2008) explored a Bayesian network representation. During the course, this network is filled with information. Chen (2008) uses a genetic-based e-learning system with personalized learning path guidance on the basis of incorrect test responses of a pre-test. Özpolat & Akar (2009) proposed an automated model to detect the learning style of a student. All prior examples make use of the Felder & Silverman model to classify learning styles.

Designing adaptive learning environments on the basis of learning styles is based on the idea that the styles are stable along time and across learning task periods. Huai (2000) experimented this hypothesis and found evidence both in literature and experimental outcomes. The use of learning styles has also been questioned: they are a simplification of the many dimensions and can hardly explain the essence of individual learning characteristics. Willingham (2009) ignored the occurrence of learning styles. Learner differences are important: in fact many of them exceed the impact factor of personality traits and sequential preferences, for example:

- their motivation to learn the subject in question (if the motivation's not there, it has to be stimulated)
- their prior knowledge of the subject (novices need more structure and support; “scaffolding”)
- the extent to which they've learned how to learn (independent learners will be much less demanding)

Some models, like the one by (Vermunt, 1992), include factors such as motivation. This reduces the stability of learning styles over time because the motivation of a student changes. He argues that four distinct learning styles can be discerned: an *undirected*, a *reproduction directed*, a *meaning directed* and an *application directed* learning style.

A recent survey (Peterson et al., 2009) on learning styles shows considerable consistency among the researchers on the potential impact of learning style in educational settings. One of them is the use of awareness about learning styles of students and teachers.

We propose to use a more adaptive form of teaching compared to Felder & Silverman and also the use of adaptive learning management systems. Our approach is to use log files from streaming video to design in real-time more adaptive learning management systems. In this way we are not dependant on previous and possibly wrong or outdated information about their learning style.

Cook (1991) examined learners' learning style awareness among a group of 78 college students in order to determine to what extent learning style awareness can be regarded in isolation of teaching styles and if these students would benefit from this awareness in terms of academic achievement. Cook found a significant difference in academic achievement in favor of the learning style awareness group.

The concept of learning style awareness was adopted in our experiment in order to enhance learning outcomes from tests. For this purpose students were confronted with their actually-performed viewing sequence.

The operational research questions:

1 - *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory?*

Earlier experiments of De Boer et al. (2008) failed to show any relationship between manifest sequential preferences and its underlying personality traits. Attempts were given to reproduce the link between short-term memory and learning styles as shown by Huai & Kommers (2001). The dominant viewing style was analyzed for students' short-term memory capacity (measured by Huai's test) and their learning styles (measured by the learning style test of Felder & Silverman).

It can be expected that students, with a higher short-term memory capacity transcend from the given chronology only at a later moment in the instructional video based upon their cognitive need. We also expected that students, who watch the instructional video in one-pass, develop a more saturated short-term memory.

2 - Do students show a consistent preferred viewing style while watching instructional videos?

To see whether the viewing style itself is a pervasive personality trait, we logged and analyzed the learners' viewing style (linear, elaboration, or maintenance rehearsal) during the confrontation with the instructional videos. The dominant registered viewing style category was defined as '*preferred viewing style'*. Interaction with the instructional video is based upon students' cognitive need so that we also looked at the test scores to see if there are differences based upon their viewing style.

We expected that students, who use more than one viewing style, score lower on the test scores.

3 - Can viewing style awareness promote higher learning outcomes?

In order to test a possible effect of awareness on learning outcomes, a group of students participated under two conditions: (Randomly chosen) half of the students got an awareness instruction and the other students did not. We expected that students who were made aware of their viewing behavior show higher learning outcomes.

4.5 Research setup

In this section the research setup of our experiment will be presented.

In this experiment, 51 undergraduate students in three groups at the Hanze University of Applied Sciences followed a nine week course about photography (Table 4.3). During one week of this course they learned how to shoot portraits with flash in a photo studio and how to use equipment for the digital darkroom and photo studio like a flashlight and a light meter. We made five instructional videos about the use of this equipment. Relevant conditions for the first and second group were kept the same. Two conditions changed for the third group in order to test the effect of awareness on their learning outcomes.

Table 4.3
The periods and the number of students that followed the course about photography

Group	Period	Nr. of students
1	February 2009 – April 2009	22
2	May 2009 – July 2009	9
3	November 2009 – January 2010	19
Total		50

The students had to follow the next three steps during this experiment:

1. Students were instructed about the learning task and the multiple-choice tests.
2. Students performed the learning task with five videos and five tests. An interview after the learning task was held about the specifics of their viewing behavior.
3. Students had to perform the short-term memory test of Huai (pictorial test and numbers and strings test) and learning style test of Felder & Silverman.

The learning task in Step 2 for this experiment consisted of a 20-minute introduction lesson with five instructional videos and five multiple-choice tests on how to use photographic equipment (Table 4.4). Students were requested to watch and pause parts of the video based upon their cognitive need in order to optimize one’s retention effect.

Table 4.4
The instructional videos used, the topics covered and the number of multiple-choice questions

Instruction video nr.	Topic covered	Length (m:ss)	Nr. of questions
1	Short introduction flashlight equipment	0:53	3
2	Flashlight equipment	0:53	3
3	Flashlight meter	1:12	3
4	Linking the flash equipment with the digital reflex camera	1:35	3
5	RAW format and photo editing software	3:30	3

After witnessing each of the instructional videos the students had to do an assignment with three multiple-choice questions with four options each. We instructed them to pause or rewind the video at the specific moment when they thought they could not answer all the questions of the multiple-choice test. Research of Verhagen (1992) described the stopping strategy of students: 69% of the students stop in order to avoid false answers to the test questions.

The short-term memory test of Huai was used to score the short-term memory of students. The validity and reliability of this test is discussed in her thesis. Another test, The Amsterdam Short-Term Memory (ASTM) test (Schagen et al., 1997) , is a test of negative response bias or insufficient effort and therefore has not been used. The short-term memory test of Huai consists of two parts. The first part is called *pictorial* test and the second part *numbers and strings* test. Both tests have about ten questions. They score recognition (multiple-choice questions) and recall (open questions). From the STM-test of Huai we used only the total of the *pictorial* test and the *numbers and strings* test.

The learning styles of students were scored using the online *Inventory of Learning Styles* of Felder & Silverman. Validity and reliability of this test is discussed by Felder & Spurlin (2005). Students filled in 44 questions online about all four dimensions of the learning style. The results of this test were returned on the screen and printed for further analysis. From the online learning style test of Felder & Silverman, all 44 questions were scored but only the 11 questions on the dimension *understanding* (sequential - global) were used. Each question is a multiple choice question with two options: one on the sequential scale and one on the global scale and one point per question. This gives a maximum score of 11 on both scales. When a student scores 1 or 3 points, he is considered well balanced on the two dimensions, 5 or 7 points a moderate preference for one dimension, and 9 or 11 points a very strong preference for one dimension.

The learning task was recorded in a usability lab (Figure 4.1) with an eye tracker. Eye tracking is normally used for testing for instance the usability of websites. Analysis of eye movements is done in relation to a specific task. In recent studies, eye tracking is also used to study cognitive processes in multimedia learning environments (Gog et al., 2009). In this experiment however, the eye tracker was primarily used as part of the so-called retrospective think-aloud method (Guan et al., 2006). In this method, students are interviewed directly after the learning task using the video recording capability of the eye tracker. This recording includes a screen capture, the eye movements, the mouse movements, the surroundings with a web-cam and the sound. The student and the researcher together view the recording immediately after the experiment. The student is therefore able to recognize his learning process and answer questions in a more objective way. We did record and used the eye movements in the interviews but ignored its data in our further analysis.

Figure 4.1 The usability lab used in the experiment

In order to measure higher learning outcomes due to awareness of learning styles, the multiple-choice test after video five was adapted. The number of questions of this test was changed from ten to twelve to avoid that too many students scored the maximum test score (clipping). The learning effects were calculated by asking the students during the last interview which multiple-choice questions they could have answered without watching the corresponding instructional video. Due to the low number of questions, a regular pre-post test could not be used. Half of the students were randomly assigned to get an awareness instruction about their viewing behavior using the retrospective think-aloud method after the fourth video.

Log files were collected on the streaming media server. After the experiment these logging data were collected into one file and imported in SPSS. Entries originating from other computers (with other IP-address than the one from the usability lab) were eliminated, the planning schedule of the experiment was used to determine the user name of the student so we could label all entries in the log files for further analysis (i.e. determination of the viewing styles from log files).

Segmentation in five parts of the instructional video was done after a pretest of the first test design. In this first design there was only one video with all five segments and a length of 8:07 minutes with an assignment with 15 multiple-choice questions at the end. Students from this pretest did stop mostly after the segment points and indicated afterwards that this was due to changing of topics and camera angle and not of possible pass at the test. This confirms the findings of Verhagen (1992): 56 % of the students in his research indicated that they stopped when an episode came to an end.

Verhagen (1992) also defined the maximum number of questions as the amount of information elements His research indicates segment length up to 22 information elements is appropriate. The teacher of the photography course created a total of 30 possible multiple-choice questions. . This also supports segmentation of the video in smaller segments with less information elements.

The instruction to the student was adapted and indicated explicitly that the test was a multiple-choice test. Some students indicated that they changed their viewing behavior of the videos after the first test where they discovered what the exact form of the assignment was. They did not articulate the recall approach and thus switched to recognition as soon as they discovered the test to be expected was a multiple-choice test. Their viewing scenario changed from two-pass to one-pass in this pretest. By adapting the instruction there was a correction for this phenomenon.

4.6 Results

In this section the experimental outcomes will be presented.

During the interviews held afterwards we asked the students about the technical and instructional quality of the instructional videos and they all assessed these as good. Care was taken not to mention facts that could influence the recall effects.

The first research question is: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory?*

Huai's finding of the relation between students' learning style and short-term memory capacity was targeted (Table 4.5). The students' short-term memory capacity was measured with the short-term memory test of Huai. The learning style was measured with the online Inventory of Learning Styles test of Felder & Silverman. When a student scores 1 or 3 points, (s)he is considered to be well-balanced on the two dimensions, 5 or 7 points a moderate preference for one dimension, and 9 or 11 points a very strong preference for one dimension.

Table 4.5
The short-term memory (STM) capacity of students and their learning styles (sequential or global)

Short-term memory capacity	Preference sequential learning style (5-11)	Balanced on both dimensions (1-3)	Preference global learning style (5-11)	Total
High STM (25.5-29.5)	0	3	1	4
Medium STM (16.0 – 25.0)	4	15	0	19
Low STM (11.5 -15.5)	1	6	1	8
Total	5	24	2	31

Students with a low short-term memory capacity are expected to have a more global learning style and student with a high short-term memory capacity are expected to have a more sequential learning style. Only one of the students falls in one of these categories. Conclusion is that the link between short-term memory and learning styles by Huai cannot be reproduced here.

A search was made for a correlation between short-term memory capacity and viewing styles in video in two ways. Firstly, we selected those students who stopped *before* the end of the video; watching until the end of a video implies that the *server* stops streaming. The viewing style belonging to this viewing behavior is *maintenance rehearsal* and we used instructional video 4, which contained the most data with maintenance rehearsals and the corresponding stopping moments in the instructional video. The Pearson correlation between short-term memory and their stopping moment is -0,11. Conclusion is that the link is weak and negative.

Next was the search for students who manifested a linear viewing style. These students did not interact with the video in order to optimize the retention. We expect that those students have a high short-term memory. Instructional videos 3 and 5 were used. Instructional video 3 contained a complex instruction about the use of a light bulb. Instructional video 5 was the longest in duration and contained the most dense information elements. Not all students with a linear viewing style displayed a high short-term memory capacity: about 40% still have a weaker short-term memory.

The conclusion is that there is not a strong correlation relationship viewing styles and pervasive personal traits like learning styles and short-term memory.

The second research question is: *Do students show a preferred viewing style while watching instructional videos?*

The *preferred* viewing style of a student has been defined as the viewing style with the highest recurrence. This was scored in four instructional videos. The first video was not used in the analysis because most students use this video to familiarize themselves with the research setup. This is an even number, so students may demonstrate two preferred viewing styles, each with two occurrences, according to our definition (Table 4.6). The viewing behavior of the three viewing styles (linear, elaboration and maintenance rehearsal) is described in Table 4.2.

Table 4.6
The nr. of students with preferred viewing styles, scored from four instructional videos

Preferred viewing style	Nr. of students
Linear	12
Maintenance Rehearsal	5
Linear and Maintenance Rehearsal	4
Elaboration	5
Linear and Elaboration	5
Total	31

From 31 students, only 22 students had a preference for one viewing style. Nine students still had a preference for two viewing styles. Following Huai (2000), we will call these students *versatiles*.

The strength (number of occurrences in the four instructional videos) of the preferred viewing style was also investigated. From 31 students, only 19 students had a strong preference for one viewing style, the rest did not.

In order to see how well the students optimized their cognitive need, the mean test score per viewing style was calculated. This mean test score is slightly higher for those students who applied the elaboration viewing style.

To see if switching viewing style lowers the test results, the total test score of the versatile students versus students was investigated with one preferred viewing styles. Switches viewing style did *not* negatively influence the test score.

Viewing style switchers were also investigated from the perspective of switching from a passive (linear) viewing style to a more active viewing style (elaboration and maintenance rehearsal) and vice-versa (Table 4.7). Most students switched to an active style while viewing instructional video 3 and 5.

Table 4.7
Test scores before and after switching viewing style in instructional video 3 and 5

Viewing style before switching	Viewing style after switching	Test score before switching	Test score after switching	Nr. of students
Linear	Maintenance rehearsal	26	26	5
Linear	Elaboration	24	28	5
Maintenance rehearsal	Linear	25	24	11
Elaboration	Linear	26	26	8

Optimizing the cognitive need of students can lead to a more active viewing style and a slightly higher test score when switching from linear viewing style to elaboration viewing style. Not all students show a preferred viewing style while watching instructional videos. Some students switch their viewing style based upon their cognitive need and this does not lower their test score.

The conclusion is that viewing styles do not correlate directly with the more pervasive learning styles as mentioned before. Switching viewing styles however does not impair the test scores.

The third research question is: *Can awareness about students' viewing style be used to achieve higher student results?*

Investigated was whether the difference in test results can be enlarged through raising the awareness level of students about their viewing styles. The same experiment was repeated as before with another group of students (N=19). Two changes were made as described in the research setup. After instructional video 4 the student was interviewed and their viewing styles were determined. Half of the students were given randomly an awareness instruction and a test with 12 multiple-choice questions (Table 4.8) was integrated. The learning effects were calculated by asking the students during the last interview which multiple-choice questions they could have answered without watching the corresponding instructional video.

Table 4.8
Learning effect of students in instructional video nr. 5, with or without an awareness instruction

	Nr. of students	Test score	Learning effect
Awareness instruction not applied	9	84.4	38.9
Awareness instruction applied	10	101.0	52.0

The test scores of students, who got an awareness instruction, are about 20% higher. Conclusion is that the learning outcomes are higher when students get an awareness instruction.

A strong correlation between the viewing styles and pervasive personal traits like the short-term of students was not perceived. Switching viewing styles however does not lower the test scores. Students can score 20% higher on the test scores through the use of an awareness instruction.

4.7 Discussion

In this section we will discuss the results from our experiments and pilots.

This experiment investigates backgrounds of the viewing behavior of students while watching instructional videos. Preferences in their viewing behavior and correlations of this behavior with pervasive personality style traits were therefore researched. Investigated also was whether learning outcomes can be enlarged through raising the awareness level of students about their viewing styles

Students from a pilot of the experimental setup stopped right after the segment transition in most of the cases. They indicated afterwards that this was due to changing of topics and camera point and not so much because of memorization for the sake of test expectations. This confirms the findings of (Verhagen, 1992): 56 % of the students in his research indicated that students mostly stopped when an episode came to an end. Verhagen defined the maximum number of questions as the amount of information elements. His research indicates that a segment length of about 22 information elements is appropriate. The teacher of the photography course created a total of 30 possible multiple-choice questions. This also supports segmentation of the video in smaller segments with less information elements.

Some students in the same pilot indicated that they changed their viewing style of the videos after the first test where they discovered what the exact form of the assignment was. They did not study with emphasis on recall but changed to recognition as soon as they discovered the test was a multiple-choice test. The essence of the conclusion is that in case of video viewing students typically lack the skills and the attitude to adapt the viewing behavior to the actual state of cognitive need during the learning process. So far it was found that viewing sequences do not reflect a trivial pattern. It raises the question how video players should elicit the learner to express the actual learning need and cognitive preference even sharper. Garcia (2008) found that students with a global learning style could benefit from reading a summary of the course materials first.

The link between short-term memory and learning styles cannot be reproduced as Huai did. There are also no strong correlations between (preferred) viewing styles and personal traits like learning styles and short-term memory. Huai did use another test (Pask's Smugglers test) in order to score the dimension serial – global. Possibly the conclusion of Graf, Lin, & Kinshuk (2008) is not correct which was the basis of our change in test. However, the Smuggler test is more time consuming to use than the real-time use of log files, so this would inhibit the use of adaptive learning management systems in real-time.

Not all students showed a preferred viewing style while watching instructional videos. Some students even seem to switch their viewing style based upon their cognitive need and this does not lower their test score. This flexibility of the student in adapting his viewing behavior is in line with the missing correlation between pervasive personality traits and learning styles found earlier in this experiment.

Interviewing students about their viewing behavior in other educational videos showed some strategy-oriented reasons. One student said: *I first watch the movie, and then I try to guess which questions will be asked and then I rewatch those specific fragments.* This example also shows that students indeed can switch flexible between viewing styles. The term *viewing strategy* is therefore proposed instead of *viewing style* to account for the flexible changing of the viewing behavior of students.

The test scores and learning effects of students, who got an awareness instruction, are about 20% higher. This is in line with the recent survey (Peterson et al., 2009) on learning styles. The student population however was so small so that we could not use analysis of covariance to compensate for distributions in the knowledge level.

Further research has to be done. Firstly, the number students in the population will be increased to investigate whether students can indeed achieve higher learning outcomes and to compensate for distributions in the knowledge level. Secondly, we will investigate how students can be made aware of their viewing behavior in such a way that it does not interfere with their learning process.

Chapter 5
Viewing video for learning

Jelle de Boer [a*], Piet A.M. Kommers [b] and Bert de Brock [c]

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[a] Institute of Communication & Media, Hanze University of Applied Sciences, Zernikeplein 7, 9747 AS, Groningen, The Netherlands
[b] Faculty of Behavioural Sciences, University of Twente, P.O. Box 217, 7500 AE, Enschede, The Netherlands
c Faculty of Economics and Business , University of Groningen, P.O. Box 800, 9700 AV, Groningen, The Netherlands

***To be submitted**,* (2013)

Thesis structure:

Chapter:	**Main conclusions:**
Chapter 1 Introduction Problem statement, research questions, and thesis structure	
Chapter 2 How to interpret viewing scenarios in log files from streaming media servers Research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*	Four viewing scenarios were recognized: one-pass, repetitive, two-pass, and a zapping scenario.
Chapter 3 How to use log files from streaming media servers to determine learning processes Research question: *Can we use log files from streaming media servers to determine learning processes from students, and is there a link with the learning style model from Vermunt?*	Students' learning processes could be monitored through the use of log files. However, we found no clear link between viewing scenarios of students and their learning style.
Chapter 4 Using learning styles and viewing styles in streaming video Research question: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness contribute higher learning outcomes?*	Viewing behavior with streaming video of students is not strongly correlated to short-term memory capacity and learning styles. Students are flexible in changing their viewing behavior. An awareness instruction enhanced their learning outcomes.
Chapter 5 Viewing video for learning Research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*	Students who demonstrate a strategic or a multiple viewing approach attain higher learning effects than students with only one viewing approach. Students with low prior knowledge of the topics are less able to enhance their metacognitive skills. Some students develop marking techniques with the mouse in the media player to watch video more strategically.
Chapter 6 Discussion Findings, implications, reflection, and future work	

In the previous chapter we showed that viewing behavior with streaming video of students is not strongly correlated with the more pervasive personal traits such as short-term memory capacity and learning styles (style-oriented). However, students proved to be flexible in changing their viewing behavior. So an awareness instruction about their viewing behavior was given to 19 students in an experiment and this enhanced their learning outcomes. This second part of the previous experiment has been scaled-up in terms of more students in the fourth experiment, which will be described in the following chapter. Furthermore, the possible role of students' prior knowledge on the topics was investigated in terms of revealed learning effects.

This brought us to the fourth experiment. We focused on the following research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*

The following chapter also proposes a new model that addresses both style and strategic elements in the manifest viewing behavior of the student. The model was based on metacognition and recent notions about the use of learning styles in education. The model was applied on a group of 115 students (including the 19 students from the previous experiment) in order to see whether learning effects differ among students with narrow or broad repertoires of viewing behaviors.

Abstract

Video is increasingly used in education. Therefore it becomes more important to improve learning of students from video. In this article we propose a model based on metacognition that distinguishes between different viewing repertoires of a student. We investigated whether learning effects of a student are influenced through an instruction about more viewing behaviors and if these learning effects depend on their prior knowledge.

In a controlled environment, 115 students watched several instructional videos. Every other student was made aware of other possible viewing behaviors (intervention). A pre-post-retention test was carried out to calculate learning effects.

Students with a broad viewing repertoire gain higher learning effects than students with a narrow repertoire. Furthermore, students with strategic viewing approach gain also higher learning effects. Students with a medium level of prior knowledge attain higher learning effects.
Students with a low level of prior knowledge seem not to benefit. Their knowledge gain disappears after a few weeks. Therefore instructions to students about their viewing and also learning behavior should not be timed too soon: students can apply this new behavior more easily when they have some basic knowledge of the topics at hand.

In our future research, we want to repeat our experiments for more complex video episodes in a classroom. Furthermore, we will define additional media player buttons to diversify the study sequence of students.

5.1 Introduction

Video is increasingly used as an instructional tool in education. Therefore it becomes more important to improve the learning process of students studying from video lessons. Students are mainly coached to enhance their learning skills from text. Video is not a popular format for “serious learning” so far. Interacting with the control buttons of a media player gives students only a few standard tools to interact (start and stop) with video, hardly supporting the learning process of students.

The role of interactive features while learning from video versus print has been investigated by Merkt, Weigand, Heier, & Schwan (2011). They showed that the effectiveness of interactive videos was at least comparable to that of print, probably due to the possibilities provided for self-regulated learning.

The experiment in this article is part of a larger research project. The experiments in this project investigate the possibilities to make learning management systems more adaptive at run-time, based on the viewing behaviors of students. In the first experiment of this project, four viewing scenarios were recognized based on anonymous entries in log files from streaming media servers (De Boer & Tolboom, 2008). One of the scenarios was *viewing by zapping* where a student seems to skim a video episode. According to earlier research (Blijleven, 2005), a broken link between the learning task and the learning process could be the underlying factor.

In the second experiment (De Boer, 2010), learning processes and tasks and the possible link with learning styles were investigated further. It demonstrated that students’ learning processes (constituting a learning task) could be monitored through the use of log files. However, there was no clear link between viewing scenarios of students and their learning style. Vermunt’s distinction of learning styles not only includes a cognitive perspective but also a self-regulating and motivational perspective.

The third experiment (De Boer et al., 2011) focused on the cognitive perspective and investigates whether the students’ viewing behavior is determined by pervasive personality traits. This recent experiment shows that viewing behavior with streaming video of students is not strongly correlated to the more pervasive personal traits such as short-term memory capacity and learning styles (style-oriented). Students proved to be flexible in changing their viewing behavior (strategic-oriented).

In the current article we propose a new model that addresses both style and strategic elements in their manifest viewing behavior and distinguishes between narrow and broad viewing repertoires. This model is based on metacognition and recent notions about the use of learning styles in education. We also applied the model on a group of 115 students in order to see whether the learning effects differ among students with a different viewing behavior.

The remainder of this article is organized as follows. Section 2 reviews the relevant literature on the use of multimedia and adaptive learning systems in learning. Section 3 presents the theory and critique on learning styles and learning strategies. Section 4 presents the new model, based on metacognition and presents the underlying research questions as well. In Section 5 the research setup is presented. Section 6 contains the results of our experiment. Finally, the discussion is delivered in Section 7.

5.2 Learning from multimedia and adaptive learning systems

Multimedia offer several possibilities to facilitate knowledge construction according to Clark & Mayer (2008). They discuss several proven guidelines such as the modality- and contiguity principle. The modality principle states that text on screen should also be presented as narrative text. Verhoeven, Schnotz, & Paas (2009) argued that comprehension through multimedia involves the parallel processing of auditory- and pictorial elements in working memory. This process of knowledge construction may depend on its imposed cognitive load. Firstly, cognitive load is determined by (a lack of) prior knowledge and motivation. Secondly, it is also determined by the load imposed by processing cognitive strategies and task demands.

Merkt et al. (2011) investigated the role of interactive features when learning with video compared to learning with print. They found that - in contrast to prior studies - the effectiveness of interactive video was at least as good as that of print, probably due to its possibilities for self-regulated information processing. Zahn, Barquero, & Schwan (2004) studied two apparently conflicting classes of design principles for instructional (hyper) videos. Their results indicate that both the browsing and knowledge acquisition were not influenced significantly by the design parameters of the video. However, individual characteristics of navigation behavior were significantly and positively correlated with knowledge acquisition.

The experiments in the research project investigate the possibilities to make learning management systems more adaptive at run-time, based on the viewing behaviors of students. As a basis for constructing more adaptive learning systems, learning styles and learning strategies are often proposed. Tseng, Chu, Hwang, & Tsai (2008) have proposed an innovative adaptive learning approach based upon two main sources of personalization, that is: learning behavior and personal learning style. Abell (2006) described a model based upon learning styles and emerging digital media in order to individualize learning with the help of intelligent agents.

Schiaffino, Garcia, & Amandi (2008) identify two main research directions for constructing more adaptive learning systems: adaptive educational systems and intelligent tutor systems. The latter ones are characterized by its continuous efforts to optimize both the system responsiveness and the learners' meta-cognitive awareness. Instead of the opportunism to adapt the medium to the latent learner traits, it provokes the learner to become more active and cope with his/her unbalanced mental trend or even mental repertoire. Adaptive educational systems accommodate the variety in the presentation of content and navigation through the student's profile. Intelligent tutor systems recommend educational activities and deliver individual feedback according to the student's profile. Schiaffino, Garcia, & Amandi proposed an agent (eTeacher) that can be considered as an intelligent tutor who unobtrusively observes the student's behavior and builds the profile.

Garcia, Schiaffino, & Amandi (2008) explored a Bayesian network representation in order to detect a student's learning style as a basis for more adaptive learning systems. During the course, this network is filled with information. Özpolat & Akar (2009) proposed an automated model in order to detect the learning style of a student. Both examples make use of the Felder & Silverman model to classify learning styles (Felder & Silverman, 1988).

5.3 Learning styles and ongoing critique

Our experiments investigate the possibilities to make learning management systems more adaptive at run-time, based on students' viewing sequences. Designing adaptive learning environments on the basis of learning styles rests upon the idea that students' learning styles are stable along time and across learning tasks. Huai (2000) tested this hypothesis and found evidences both in literature and experimental outcomes.

The use of learning styles has also been questioned: they are a simplification of the many dimensions and can hardly explain the essence of individual learning characteristics. Willingham (2009) ignored the existence of learning styles: differences across learners are important however. In fact many of them exceed the impact factor of personality traits and sequential preferences according to Willingham (2009):

- the student's motivation to learn the subject in question
- the student's prior knowledge of the subject (novices need more structure and support)
- the extent to which the student has learned how to learn (independent learners will be much less demanding)

The British agency Becta (2005) researched the literature on learning styles and reviewed some definitions and elements of learning style: information processing, instructional preferences, and learning strategies. Although they found it difficult to evaluate such a diverse and complex area of theory, the following ingredients seemed to be consistent after all:

- Despite the many opinions on learning styles there are few generally agreed facts. Some theories are more influential than others, but no model of learning style is universally-accepted, as in this complex area reliable studies are lacking.

- Any theory or model of learning styles is necessarily a reduction of the complexity of how students learn.
- Learning styles are at best one of a range of factors determining how learners react to learning opportunities: the environment, culture (both of the learner and his/her institution). Teaching methods and curriculum requirements are all part of a complex pattern of interactions.
- There is an inherent danger in learning styles in labeling students as belonging to particular kinds of learners: Given the lack of robust evidence in the field, labeling strategies seems safer than labeling learners.
- Student's awareness of learning styles theories may help to develop metacognition and the ability to learn how to learn.

The British agency Becta (2005) concluded that the fundamental difference between those who believe in fixed learning styles and those who believe in flexible learning strategies lies in the following approach: instead of adapting teaching and content to the learner, the learner needs to choose the approach that is most appropriate for the requirements of the task at hand.
They also concluded that encouraging metacognition (being aware of one's own thought and learning processes) is perhaps the most important advantage that can be claimed for applying learning styles theory to learning and teaching.

A recent survey (Peterson et al., 2009) on learning styles shows a considerable consistency among the researchers on the potential impact of learning style in educational settings. One of them is the use of awareness about learning styles by students and teachers.

Our initial experiment (De Boer & Tolboom, 2008) did not show any relationship between manifest sequential preferences and its underlying personality traits. Our second experiment (De Boer, 2010), demonstrated that students' learning processes (constituting a learning task) could be monitored through the use of log files. However, there was no clear link between viewing scenarios of students and their learning style. The link between short-term memory and learning styles according to Huai could not be reproduced (De Boer et al., 2011) . There were no significant correlations between (preferred) viewing styles and personal traits such as learning styles and short-term memory capacity. Some students switched their viewing style due to their cognitive need. However, it did not lower their test score.

This student's flexibility in adapting his viewing behavior is in line with the missing correlation between pervasive personality traits and learning styles as we found earlier. The term *viewing strategy* was proposed by De Boer et al. (2011) instead of *viewing style,* in order to account for the flexible, conscious, and strategic changing of the viewing behavior of students.

Examples of different styles of behavior can also be found in management. Tannenbaum and Schmidt (1973) distinguished several types of leadership behavior. These behaviors range from boss-centered leadership along to subordinate-centered leadership. It reflects how managers treat their workers. Tannenbaum and Schmidt (1973) also argued that the style of leadership is dependent on existing circumstances. Managers should find their management style that suits best their personality as well as the business needs and the circumstances at hand. The best advice according to (Cox, 2010) is to combine elements of all styles, or at least a few of the styles, depending on the circumstances. This leads to a management *strategy* instead of a (fixed) management *style*.

5.4 Awareness and metacognition

Awareness and metacognition are examples of the ability of students to monitor and control their learning behavior. Efklides (2006) decomposed metacognition into three components:

- Metacognitive *knowledge* (monitoring learning behavior) is what individuals know about themselves and others as cognitive processors.
- Metacognitive *experiences* (monitoring learning behavior) are those experiences that have something to do with the current, on-going cognitive endeavor.
- Metacognitive *regulation* (controlling learning behavior) is the regulation of cognition and learning experiences through a set of activities that help people control their learning endeavor.

Metacognition refers to a level of thinking that involves active control over the process of thinking that is used in learning situations (Efklides, 2006). Examples of metacognitive skills are: planning the way on how to approach a learning task, monitoring understanding, and evaluating the progress at the end of a learning task. Students who are able to use a wide range of metacognitive skills score higher on exams and complete learning tasks more efficiently (Efklides, 2006).

De Boer (2011) introduced the term ‘viewing strategy’ when a student shows signs of strategic viewing behavior. We can apply this to an example of such a typical student: *I first watch the movie, and then I try to guess which questions will be asked and then I watch those specific fragments again.* This viewing behavior is strategic in the sense that the student consciously plans at the beginning of a viewing session to list the fragments to be watched again at the end of the video. He also monitors his learning behavior (metacognition). We add this strategic viewing behavior (Table 5.1) to our four earlier defined viewing styles: Zapping, Linear, Maintenance Rehearsal, and Elaboration (De Boer et al., 2011).

Students can exhibit more kinds of strategic viewing behavior but this was the predominant one in our experimental setting with relatively short videos. In the interviews held afterwards, students mentioned often a strategy to learn a software program with the help of a long video tutorial: they stopped the video after some time to exercise the content in the video and continue afterwards.

Table 5.1
Viewing styles and viewing behavior.

Viewing style	Viewing behavior
Linear	a student watches a video in one pass (uninterruptedly) from the beginning to the end
Elaboration	a student watches a video again after finishing the first time in one-pass
Maintenance Rehearsal	a student watches parts of a video repeatedly
Zapping	a student skims the instructional video at intervals of relatively short viewing times
Strategic	a student e.g. watches a video in one pass (uninterruptedly) from the beginning to the end, and then watches one or more specific segments again

Kozhevnikov (2007) explored trends in cognitive style research that have emerged to examine superordinate cognitive styles (meta styles). It defines the extent to which individuals exhibit flexibility and self-monitoring in their choice of styles.

More recently, Moskvina and Kozhevnikov (2010) gave an overview of the historical perspectives and directions for future research. They redefined the concept of cognitive style as ontogenetically flexible individual differences representing an individual's adaptation of innate predisposition to external physical and socio-cultural environments.

We propose to classify the (combined) use of our viewing behaviors, based on the previous metacognition model and the conclusions about learning behavior in the earlier sections of the next model.

- a student can exhibit only one specific viewing behavior (e.g. either linear or elaboration) and not a *strategic* viewing behavior (*one-trick viewers*)
- a student can exhibit several viewing behaviors (e.g. linear and elaboration) but not a *strategic* viewing behavior (*multi-trick viewers*)
- a student can exhibit specific viewing behaviors (e.g. linear and maintenance rehearsal) as part of a *strategic* viewing behavior (*strategic viewers*)

The *one-trick viewer*s have a narrow viewing repertoire and the *multi-trick* and *strategic viewers* have a more broad viewing repertoire.

Cook (1991) examined learners' learning style awareness among a group of 78 college students in order to determine to what extent learning style awareness can be regarded in isolation of teaching styles and whether these students would benefit from this awareness in terms of academic achievement. Cook found a significant difference in academic achievement in favor of the learning style awareness group.

The concept of learning style awareness has been adopted in our earlier experiment (De Boer et al., 2011) in order to enhance learning effects. We checked whether learners' awareness of their actual viewing style potentially contributed to learning effects. No strong correlation between the viewing styles and pervasive personal traits of students was perceived. Some students switched their viewing style based upon their cognitive need, without lowering their test score. The flexibility of the student to adapt his viewing behavior might have led to the missing correlation between pervasive personality traits and viewing styles. Students scored 20% higher on the test scores after using an awareness instruction.

The number of students in the population has been increased in the experiment of this article to investigate whether students can indeed achieve higher learning effects using an awareness instruction. Furthermore, we investigated the effect of the prior knowledge level on these outcomes as De Boer et. al. (2011) suggested. Based on the research of Salomon (1984) we expected that students with a high level of prior knowledge would reach a higher score of learning effects. Finally, we checked whether students with a strategic or multi-trick viewing behavior have higher learning effects than students with a one-trick viewing behavior.

Students watched several instructional videos in a controlled environment (usability lab). During an interview after the fourth and before the last and fifth instruction video, every student was confronted with a video recording of their actually-performed viewing behavior during the first four instruction videos. During this interview, every other student (intervention - versus the control group) was also made aware of the possible use of alternative viewing behaviors during the last instruction video to enhance learning effects. A pre-post-retention test was taken after the last video to calculate learning effects.

During the analysis three types of students emerged:

1 The first type of student (*good student*) is defined as: (s)he achieves a very high score on our multiple-choice tests and uses a one-trick viewing behavior. Because their score is already high, there is no need to change their *one-trick* viewing behavior to more elaborate viewing behavior like *multi-trick* or *strategic* viewing behavior.

2 The second type of student (*bad student*) is defined as: (s)he achieves a very low score on our multiple-choice tests and is using *multi-trick* and/or *strategic* viewing behavior. Their score is already low while using more elaborate viewing behavior.

3 The rest of the students (*students with room for improvement*) belong to the third type.

The use of alternative viewing behaviors will be most effective in terms of test scores on students of the third type. This classification was done because some very good students (cognitive and metacognitive) appeared in the non-intervention group. This could occur because every other student was chosen for the awareness instruction. The classification was based on the viewing behavior of the first four videos to eliminate the effect of the intervention and the test score of the fifth multiple-choice test. The fifth test had the highest number (twelve) of multiple-choice questions, whereas the other multiple-choice tests only had four each. We applied this classification to both groups (intervention and non-intervention) to avoid skewing of the results.

In general, the group students of type one and two should not be withheld from video as a tool for learning. Possibly, the reasons for low test scores are other types of causes such as motivation. Therefore, we suggest also other types of measures such as coaching in order to compensate for these deficiencies.

The research questions for the underlying experiment are:

1 – What is the difference in learning effects between students with and without an awareness instruction on an alternative viewing behavior?
The number of students in the population has been increased in the experiment of this article in order to investigate in more depth whether students can achieve higher learning effects indeed. An awareness instruction on an alternative viewing behavior has been given to every other student. It is expected that students, who get this awareness instruction attain higher learning effects.

2 - What is the effect of the students' level in prior knowledge on the learning effects?
We want to investigate the possible influence of prior knowledge on the learning effects of a student. The pretest score is a proxy for this prior knowledge level.

3 – What is the difference in retention decay between students with and without an awareness instruction on an alternative viewing behavior?
Between three and four weeks after the posttest, a retention test was held in order to see how far the post test effect became extinct and whether the intervention (awareness) factor had any influence on this.

4 – *Do multi-trick and strategic viewers achieve higher learning effects than one-trick viewers?*
The viewing behaviors of students were scored with the metacognitive model

described earlier and the learning effects of students with a multi-trick and strategic viewing behavior were investigated and compared with one-trick viewers.

5.5 Research Setup

In this experiment, 115 undergraduate students at the Hanze University of Applied Sciences followed a nine week course about photography (Table 5.2) in four periods: three periods of the academic year 2010-2011 and one in the academic year 2009-2010.

Table 5.2
The four periods and the number of students that followed the course about photography.

Quarter	Period	Nr. of students
3	March 2010 – April 2010	19
1	September 2010 - November 2010	38
2	December 2010 - February 2011	28
3	March 2011 – April 2011	30
Total		115

During one week of this course they learned about portrait photography in a photo studio and how to use equipment for the digital darkroom and photo studio such as a flashlight and a light meter. We made five instructional videos about the use of this equipment (Table 5.3).

Table 5.3
The instructional videos used, the topics covered and the number of multiple-choice questions.

Instruction video nr.	Topic covered	Length (m:ss)	Nr. of questions
1	Short introduction to flashlight equipment	0:53	4
2	Flashlight equipment	0:53	4
3	Flashlight meter	1:12	4
4	Linking the flash equipment with the digital reflex camera	1:35	4
5	RAW format and photo editing software	3:30	12

The students underwent the next two steps during this experiment:

1 Students were instructed on the learning task and the multiple-choice tests.

2 Students performed the learning task based upon five videos and five tests.

The learning task in Step 2 for this experiment consisted of a 20-minute introduction lesson with five instructional videos and five multiple-choice tests on how to use photographic equipment. Students were requested to watch the instructional videos based upon their cognitive need in order to optimize their learning effect. After witnessing each of the five instructional videos the students had to undergo an assignment with multiple-choice questions with four options each.

Research of Verhagen (1992) described the stopping strategy of students: they stop and watch parts of the video again in order to avoid false answers to the test questions. Zhang, Zhou, Briggs, & Nunamaker (2006) found comparable results more recently.

A first interview for every student was taken between the fourth and the fifth instructional video. Every *other* student was assigned to get an awareness instruction during this first interview about their viewing behavior: (s)he was made aware of the existence of alternative viewing behaviors. A second interview for every student was taken after completing the learning task on the typical aspects of their viewing behavior.

The learning task was recorded in a usability lab (Figure 5.1) with an eye tracker. Eye tracking is normally applied for tracing the user's eye movement e.g. during reading. In recent studies, eye tracking is also used to study cognitive processes in multimedia learning environments (Gog et al., 2009). In the underlying experiment, the eye tracker was used as part of the so-called retrospective think-aloud method (Guan et al., 2006). In this method, students are interviewed directly after the learning task using the video recording capability of the eye tracker. This recording includes a screen capture, the eye movements, the mouse movements, the surroundings with a webcam, and the surrounding sound with a microphone. The student and the researcher together view the recording immediately after the experiment. The student is therefore able to recognize his learning process and answer questions in a more objective way.

We recorded and used the eye movements in the interviews but ignored the quantitative data (e.g. position on screen, distance from screen) in our further analysis. However, we did use the video recordings afterwards to study the strategic viewing behavior of the student and the position of the fixation points on the screen. Towards the end of the video some students checked the progress bar of the media player.

Figure 5.1
The usability lab used in the experiment.

In order to measure learning effects a pre-post test was designed. Due to the low number of questions, a regular pre-post test could not be used. In order to measure posttest scores, we used the regular score of the multiple-choice test after the last instruction video. The pretest score was calculated by asking the students during the last interview which multiple-choice questions they could have answered without watching the corresponding instructional video.

The (*absolute) learning effect* is defined as the posttest score minus the pretest score. In order to distinguish between students with the same absolute learning effects, we also related the absolute learning effect to the maximum possible learning effect of a student in the test (Figure 5.2). This maximum possible learning effect is the maximum possible score of a test minus the pretest score of a student, i.e. the maximum that a student could learn in that situation.

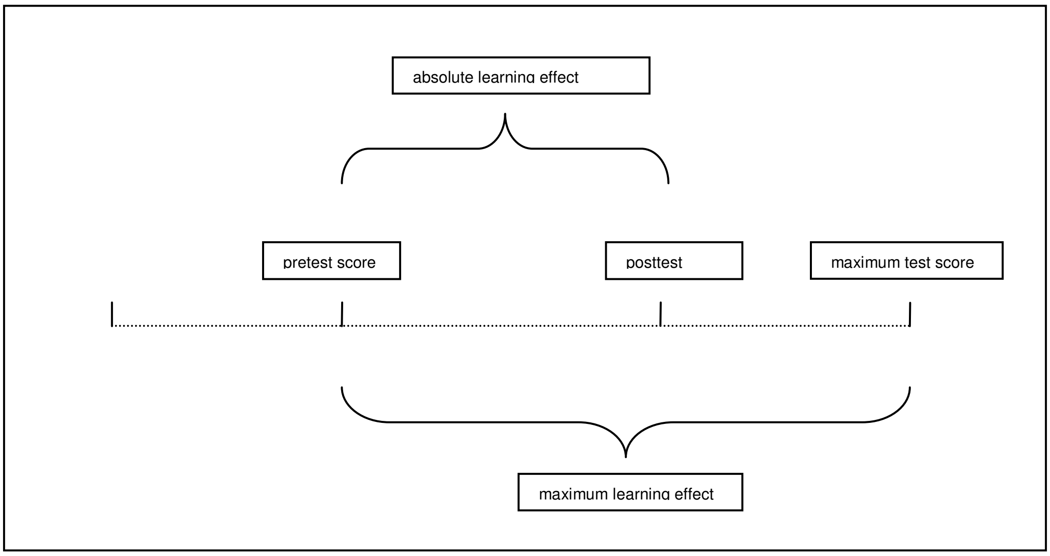

Figure 5.2
The absolute learning effect and maximum learning effect.

We define the *relative learning effect* as the quotient of the absolute learning effect (posttest score minus pretest score) and the maximum possible learning effect (max score minus pretest score).

For instance: if a student has a pretest score of 40 and a posttest score of 80 (maximum score of the test is 120) his absolute learning effect is 40 (80-40) and his relative learning effect is 0.50 (80-40/120-40), i.e. that student learned 50% of what (s)he could have learned. For another student, with a pretest score of 80 and a posttest score of 120 (maximum 120) the absolute learning effect is *also* 40 (120-80) but the relative learning effect is now 1.00 (120-80/120-80), i.e. that student learned 100% of what (she) could have learned.

These two examples show that two students, with the *same* absolute learning effect, can have *different* relative learning effects. The *relative* learning effect also aligns with the awareness instruction where a student has to enhance their learning effects to his/her best. We are aware that the relative measure emphasizes outcomes for high pretest scores (see two previous examples). We will use both measures in our further analysis to get a more complete picture of the learning effects of a student.

After three to four weeks a retention test was taken. It was the same one as the post test. The *absolute retention decay* is calculated as the posttest score minus the retention score. For instance: if a student had a posttest score of 90 and a retention score of 60, his/her absolute retention decay is 30. This absolute retention decay has also been rescaled to a relative measure. We define the *relative retention decay* as the quotient of the absolute retention decay and the posttest score. For instance: if a student had a posttest score of 90 and a retention score of 60, his/her relative retention decay is 0.50. We will use both measures in our further analysis to get a more complete picture of the retention decays of a student.

5.6 Results

In total 115 students from the Hanze University of Applied Sciences were involved and participated in an elective course about photography between March 2010 and April 2011 (Table 2). The students originated from different faculties of the Hanze University. In our dataset 19 students from our earlier experiment were included (De Boer et al., 2011). ANOVA was used in order to test the differential learning effects between the four periods and revealed no significant differences between these four periods, $F(3, 111) = 0.50$, $p=0.68$.

In the interviews held afterwards, the students were asked to rate both the technical and the didactical quality of the instructional videos. On a scale from 1-10, the technical quality was rated with a 7.9 and the didactical with a 7.6. So the overall quality of the videos can be assessed as good and this will not be a cause for any additional interruptions of the video by the student (e.g. a student couldn't hear a specific fragment due to low quality of the audio and rewinds the video).

The first research question was: *What is the difference in learning effects between students with and without an awareness instruction on an alternative viewing behavior?*
During the analysis three types of students emerged as described earlier. The first type of student has a high cognitive score and low metacognitive sore. The second type of student has a low cognitive score and a high metacognitive score. The rest of the students belong to the third type.
The level to distinguish the students from Type 1 was: the posttest score is ≥ 110, and the viewing behavior was one-trick viewer in the first four videos (N=9). The level to distinguish the students from Type 2 was: the posttest score was ≤ 80, and the viewing behavior was either multi-trick viewer or strategic viewer (N=3). We focused our analysis on the remaining students of type three (N=102).

Table 5.4
Learning effects: The absolute learning effect (difference between the posttest and pretest score) and the relative learning effect (absolute learning effect divided by the maximum learning effect).

	N	Absolute learning effect (mean)	Std. deviation	Relative learning effect (mean)	Std. deviation
Awareness instruction	52	47.1	20.0	70.7 %	18.1
No awareness instruction	50	46.6	23.9	66.6 %	23.4
Total	102	46.8		68.6 %	

The difference in relative learning effects between both groups (Table 5.4) shows a small trend, $t(92.3) = 0.98$, $p = 0.33$. The absolute learning effect does not, $t(95.6) = 0.12$, $p = 0.91$. The differences of our earlier experiment (De Boer et al., 2011) could not be reproduced on the same scale. As suggested by De Boer et al. we will also investigate the effect of the prior knowledge level.

The second research question is: *What is the effect of the students' level in prior knowledge on the learning effects?*
We wanted to investigate the effect of the prior knowledge level on the learning. The pretest score is a proxy for the level of prior knowledge. The students were divided into four groups: very low (0-30), low (40-60), middle (70-90), and high pretest scores (100-120). We investigated both the *absolute* learning effect (Table 5.5) and the *relative* learning effect (Table 5.6).

Table 5.5
Absolute learning effects: The students were divided into four groups: very low (0-30), low (40-60), middle (70-90), and high pretest scores (100-120).

	Awareness instruction			No awareness instruction		
Pretest group	Absolute learning effect (mean)	N	Std. deviation	Absolute learning effect (mean)	N	Std. deviation
Very low (0-30)	70.9	11	12.2	74.2	12	14.4
Low (40-60)	48.9	26	13.7	49.6	23	11.4
Middle (70-90)	28.5	13	10.7	20.8	13	15.0
High (100-120)	15.0	2	7.1	15.0	2	7.1
Total	47.1	52	20.0	46.6	50	23.9

We ignored the results of the students with high prior knowledge due to the low number of students (N=2). We do see a trend for higher *absolute* learning effects (Table 5.5) for students with middle prior knowledge and almost no differences for the students with low and very low prior knowledge, $t(21.7) = 1.508$, $p = 0.146$. Conclusion is that students with middle prior knowledge benefit from an awareness instruction on an alternative viewing behavior and the other students do not.

Table 5.6
Relative learning effects: The students were divided into four groups: very low (0-30), low (40-60), middle (70-90), and high pretest scores (100-120).

	Awareness instruction			No awareness instruction		
Pretest group	Relative learning effect (mean)	N	Std. deviation	Relative learning effect (mean)	N	Std. deviation
Very low (0-30)	74.3 %	11	12.1	76.2 %	12	14.9
Low (40-60)	70.3 %	26	15.8	70.5 %	23	11.3
Middle (70-90)	63.7 %	13	23.4	49.6 %	13	35.4
High (100-120)	100.0 %	2	0.0	75.0 %	2	35.4
Total	70.7 %	52	18.1	66.6 %	50	23.4

We also see a trend for higher *relative* learning effects (Table 5.6) for students with middle level prior knowledge and hardly any differences for the students with low and very low prior knowledge, $t(20.8) = 1.2$, $p = 0.244$.
Conclusion is that students with middle prior knowledge benefit from an awareness instruction on an alternative viewing behavior and the other students do not.

The third research question is: *What is the difference in retention decay between students with and without an awareness instruction on an alternative viewing behavior?*
Between three and four weeks after the posttest, a retention test was given in order to see whether the knowledge level had decayed and whether the prior knowledge level and the intervention (awareness) had any influence on this. The test was sent via email to those who were not present. The differences between the retention learning decays - taken in class and sent through mail - were not significant.

Table 5.7
Retention decay: The absolute retention decay (posttest test score minus retention score) and the relative retention decay (absolute retention decay divided by the posttest score).

	N	Absolute retention decay (mean)	Std. deviation	Relative retention decay (mean)	Std. deviation
Awareness instruction	41	11.2	16.9	10.9 %	17.5
No awareness instruction	45	14.2	17.1	14.3 %	18.2
Total	86	12.8	17.0	12.6 %	17.8

The absolute retention decay of the non-awareness intervention group has regressed 3 points more (Table 5.7). The relative retention decay of the non-awareness intervention group has regressed 3.5 % more. Both differences are small.

It was also investigated whether the knowledge level was of any influence on the retention decays.

Table 5.8
Absolute retention decay: The absolute retention decay is the posttest test score minus the retention score. The students were divided into four groups: very low (0-30), low (40-60), middle (70-90), and high pretest scores (100-120).

	Awareness instruction			No awareness instruction		
Pretest group	Absolute retention decay (mean)	N	Std. deviation	Absolute retention decay (mean)	N	Std. deviation
Very low (0-30)	22.9	7	13.8	13.6	11	19.6
Low (40-60)	9.6	22	18.6	15.3	19	16.5
Middle (70-90)	6.0	10	13.5	13.1	13	18.4
High (100-120)	15.0	2	7.1	15.0	2	7.1
Total	11.2	41	16.9	14.2	45	17.1

We ignored the results of the students with *high* prior knowledge due to the low number of students (N=4). The absolute retention decay of students from the awareness intervention group and *very low* knowledge level (Table 5.8) group seems lower than the absolute retention decay of students from the non-awareness intervention group, $t(15.7) = 1.17$, $p = 0.260$. The absolute retention decay of students from the awareness group and *low* knowledge level (Table 8) group seems higher than the absolute retention decay of students from the non-awareness group, $t(39.0) = -1.04$, $p = 0.303$.
The absolute retention decay of students from the awareness intervention group and *middle* knowledge level (Table 5.8) group seems higher than the absolute retention decay of students from the non-awareness intervention group, $t(21.0) = -1.06$, $p = 0.30$.

Table 5.9
Relative retention decay: The relative retention decay is the absolute retention decay divided by the posttest score. The students were divided into four groups: very low (0-30), low (40-60), middle (70-90), and high pretest scores (100-120).

	Awareness instruction			No awareness instruction		
Pretest group	Relative retention decay (mean)	N	Std. deviation	Relative retention decay (mean)	N	Std. deviation
Very low (0-30)	24.0 %	7	13.7	13.8 %	11	22.8
Low (40-60)	9.1 %	22	19.6	14.9 %	19	16.3
Middle (70-90)	5.6 %	10	12.8	13.1 %	13	19.3
High (100-120)	12.5 %	2	5.9	13.3 %	2	7.0
Total	10.9 %	41	17.5	14.0 %	45	18.2

Comparable conclusions about the relative retention decay can be drawn from Table 5.9.

Conclusion is that is a trend that the retention decay seems higher through an awareness instruction on an alternative viewing behavior for students with very low prior knowledge level and higher through an awareness instruction on an alternative viewing behavior for students with low and middle prior knowledge level.

The last research question is*: Do strategic viewers achieve higher learning effects than non-strategic viewers?*
The viewing behavior of the students was scored also with the metacognitive model described earlier and compared with their learning effects. We used the total

population as earlier and did not compare the intervention group because in the intervention group there was only one student left with one-trick viewing behavior.

Table 5.10
Metacognitive model: Viewing Behavior and Learning effects. The absolute learning effect (difference between the posttest and pretest score) and the relative learning effect (absolute learning effect divided by the maximum learning effect).

Viewing behavior (metacognitive)	N	Absolute learning effect (mean)	Std. deviation	Relative learning effect (mean)	Std. deviation
One-trick viewers	16	40.6	24.4	53.1 %	24.7
Multi-trick viewers	23	47.9	22.4	73.2 %	16.1
Strategic viewers	63	48.1	21.2	71.0 %	19.9
Total	102	46.0	21.9	68.7 %	20.9

The difference in relative learning effects between students (Table 5.10) with one-trick and multi-trick viewing behavior is significant, $t(23.7) = -2.86$, $p = 0.009$. The difference in absolute learning effect however is less significant, $t(30,6) = -0.939$, $p = 0.355$ due to high unequal variances.
The difference between multi-trick and strategic viewers is small.

Students with a strategic and multi-trick viewing behavior score higher absolute and relative learning effects than students with a one-trick viewing behavior. Furthermore, the fraction of strategic viewers is high (over 60%).

Finally, the retention decays were investigated.

Table 5.11
Metacognitive model: Viewing behavior and retention decay. The absolute retention decay (posttest test score minus retention score) and the relative retention decay (absolute retention decay divided by the posttest score).

Viewing behavior (metacognitive)	N	Absolute retention decay (mean)	Std. deviation	Relative retention decay (mean)	Std. deviation
One-trick viewers	14	13.6	18.7	15.1 %	21.6
Multi-trick viewers	21	10.0	19.7	9.4 %	20.3
Strategic viewers	51	13.3	15.6	13.1 %	15.8
Total	86	12.8	17.0	12.6 %	17.8

Conclusion is that the difference in both retention decays between multi-trick and strategic viewers is small. The students with a one-trick viewing behavior have the lowest scores (Table 5.11). The differences in absolute and relative retention decays however are small.

During the interviews held afterwards, ten ‘strategic viewers’ described in an open answer their viewing behavior almost exactly as defined in our metacognitive model. Furthermore, five of the multi-trick viewers also described that they would have viewed in a strategic way if the buffering of videos wasn’t present and six students pointed out that they would use strategic behavior with longer videos. Finally, five students described some techniques that helped them when viewing video in a strategic way: e.g. they used the mouse as marking point on the progress bar to help them remembering the segments to watch again. Two students indicated that the quality of videos was already quite good; so they experienced no need to watch segments again.

5.7 Discussion

The learning effects of 115 students have been investigated. The study extrapolates an earlier experiment of 19 students (De Boer et al., 2011). The results have been collected during four different periods. As expected, the effect of period did not have any influence on the difference in learning effects.

The group of students who got an awareness instruction on an alternative viewing behavior scored slightly higher learning effects than those students without an awareness instruction. The differences of our earlier experiment (De Boer et al., 2011) however could not be reproduced with the same magnitude.

A further investigation was made on whether there was any influence of the prior knowledge level on the learning. Students, who got an awareness instruction on an alternative viewing behavior and those with a medium level of prior knowledge, showed a trend to achieve higher learning effects as students who didn't get an awareness instruction. Students, who got an awareness instruction and with very low and low prior knowledge, achieved the same learning effects as students with didn't get an awareness instruction.

Our result is similar to the results of Cook (1991). She also gave students tips about their learning behavior based on their learning styles and found significantly higher learning effects. We did not use study tips based on the student's learning style but suggestions about their viewing behavior based on our metacognitive model however. Research of Salomon (1984) shows a comparable effect where students with high prior knowledge can be challenged to show their higher knowledge.

The retention decays were also included in the analyses. Looking at these retention decays of the group with very low prior knowledge we see that students, who got an awareness instruction, remember less than the students without an awareness instruction. It seems that students with lower prior subject knowledge are less capable to enhance their metacognitive skills at the same time when learning from video. Their knowledge construction is worse when doing two things at the same time (cognition and metacognition) which is in line with the cognitive load theory of Sweller (2004). Therefore instructions to students about their viewing and also learning behavior should not be timed too soon: students can apply this new behavior more easily when they have some basic knowledge of the topics at hand.

Furthermore, the learning effects of students, based on our metacognition model, were investigated. It was found that the multi-trick and strategic viewers achieve higher learning effects than the one-trick viewers. We would have expected that the learning effects of the strategic viewers would be higher than the result of the multi-trick viewers too. Some students indicated in interviews that they changed their viewing behavior from strategic to the multi-trick approach due to its interaction complexity: buffering for instance was sometimes a nuisance when searching for a specific element in the video. So in our experiment, both types of viewing behavior sometimes seem to have similar learning effects. One of the technical reasons for this buffering of the streaming video server is that we configured it in such a way that buffering of the local client was not possible. We did this to monitor the clicking behavior also in the log files of the server. Under normal conditions, we suggest not to use these settings.

Not all differences reached a level of significance. One possible explanation was the pre-, post- and retention test lacked a sufficient complexity of the test items. However, increasing the number of test items would also have increased the number of information elements and thus the length of the video. The increased length would lead to segmenting of this new and longer instruction video (Verhagen, 1993). So we kept the length of the video the same.

We calculated the prior knowledge (pretest score) by asking the students, directly after the last multiple choice test, which questions they could have answered without watching the corresponding instructional video. In order to measure the posttest score, we used the regular score of the multiple-choice test.

Answering the questions about their pretest score was done well by students. It could be expected that students should be less able in reconstructing their prior knowledge after the test but this was not the case.

The difference in both retention decays between multi-trick and strategic viewers is small. The students with a one-trick viewing behavior have the lowest scores. The differences in absolute and relative retention decays however are small. One possible explanation also was the pre-, post- and retention test lacked a sufficient complexity of the test items.

The retention test was not taken in the same controlled situation as the post test. The test was taken in class and via mail due to organizational circumstances. Repeating our experiment, we would have kept the circumstances for the post and retention test the same: so both in the usability lab or both in class. For our experiment however, the differences were small between the lab and class situations.

A large proportion of the experimental subjects exhibited the strategic viewing behavior. So after watching the video in one pass, they watched specific parts of the video again. Some of them used the mouse as marking point on the progress bar to help them remembering the segments to watch again. In general, video players should offer more options for helping students in their search for the content they want to watch again. This could be done by linking the starting points of the segments of a video with the progress bar. Furthermore, the segments could also be presented at the end of the video to give them an opportunity to watch specific segments again. Such a list could also be presented at the start of a video to give an overview of the contents (Ausubel, 1960). Finally, also external links to other videos should be embedded in the video in order to help the student with learning from video (Zahn et al., 2004).

Students who demonstrate the multi-trick viewing behaviors exhibit more interaction with the media player than those with one-trick viewing behavior. These multi-trick viewers are supposed to use the strategic tools less because switching their viewing behavior can be done with the regular buttons (rewind or play) of the media player. At the other hand, some of these students indicated that due to buffering of streaming video they gave up the strategic viewing behaviors.
In order to improve learning from video, it is also necessary to improve the quality of the video itself when appropriate. Some students indicated that they would have used alternative viewing behaviors than one-trick viewing behavior when the

videos would have been not so good. So the viewing behavior of all students can be considered as a symptom of the quality of the instructional videos.

Buffering of videos on the local client should be used as much as possible. Finally, the criterion of distinguishing strong and weak students should be applied as early as possible so that coaches can help students with their viewing and learning behavior. In this way students can be coached to take a more active study stand when learning from video.

In our future research, we first want to implement the new requirements for a didactically-enhanced media player. In this way we can better implement our findings to students for helping them with strategic viewing behavior. Furthermore, we want to apply this to another (set of) videos which are not as "smooth" as the ones we used. In this way the need for students to interact with the videos will be a more natural one. Strategic viewing can sometimes be the only option left for students when confronted with demanding videos.

Chapter 6
Discussion

This chapter summarizes the relevant findings from the experiments and elaborates its further implications for Higher Education. In Section 6.1 the findings will be presented and summarized. Theoretical implications will be discussed in Section 6.2 and the practical implications for Higher Education in Section 6.3. Finally, we will present the limitations of our research setting in Section 6.4 and our future research in Section 6.5.

6.1 Findings of the experiments

In this Section, the most relevant findings from the four experiments (presented in Chapter 2 - 5) will be presented and summarized.

The first research question was*: Which viewing scenarios can be recognized in log files from streaming media servers?*

The following four viewing scenarios could be recognized through explorative analysis of the log files from the streaming media server (Table 6.1):

Table 6.1
Viewing scenarios and viewing behavior

Viewing scenario	Viewing behavior
One-pass Scenario	a student watches a video in one pass (uninterruptedly) from the beginning to the end
Two-pass Scenario	a student watches a video again after finishing the first time in one-pass
Repetitive Scenario	a student watches parts of a video repeatedly
Zapping Scenario	a student skips through the instructional video at intervals of relatively short viewing times

With a questionnaire the use of these scenarios was further investigated. We asked the student which scenario they used most. Most students (60 %) indicated to use the repetitive scenario. Some of them indicated to use the one-pass (17%) or the two-pass scenario (22%).

None of them said to use the zapping scenario most, but there were traces in the log files indicating that students did use this scenario. The zapping scenario, where a student skims a video episode, is similar to the learning behavior of a student with the undirected learning style from Vermunt (1992). According to Blijleven (2005), a broken link between the learning task and learning process could be the underlying factor. Therefore, learning processes and their possible link with learning styles were investigated further in the second experiment.

The second research question was: *Can we use log files from streaming media servers to determine learning processes from students and is there a link with the learning style model from Vermunt?*

A learning task was designed to monitor the learning processes of students. This task (about 45 minutes in length) consisted of four subtasks. The corresponding learning process of a student has been defined as a sequence of viewing scenarios.

Results showed that for almost all students, this sequence of viewing scenarios - based on the answers from the semi-structured interviews - is the same as when analyzing the log files. So we could use log files from streaming media servers to determine learning processes from students in this experiment.

There was no apparent link between the zapping scenario and the undirected learning style model from Vermunt. Vermunt's distinction of learning styles not only includes a cognitive but also a self-regulating and a motivational perspective.

Based on the research of Huai (2000), our focus changed from learning styles to more pervasive personality traits such as cognitive styles and the short-term memory of students. Huai found a correlation between these two traits. It can be expected that students with a higher short-term memory capacity transcend from the given chronology at a later moment in the instructional video based upon their cognitive need. This brought us to the third experiment.

The third research question was: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness promote higher learning outcomes?*

Two viewing styles were introduced by correlating the two viewing scenarios to two relevant learning strategies from Craik & Lockhart (1972): *maintenance rehearsal* and *elaboration*. Maintenance rehearsal is the strengthening of elements in the short-term memory through repetition. Elaboration is the meaning-oriented rehearsal using related knowledge from long-term memory.
The elaboration learning strategy is similar to the two-pass viewing scenario (recruiting semantically-related knowledge from one's long-term memory), often labeled as a process of meaningful elaboration.
The maintenance rehearsal approach learning strategy is similar to the repetitive

viewing scenario through the refreshing of memory. A viewing scenario based upon rehearsal implies that a student needs support based on the chronological order of the video segments.

Some students showed signs of strategic viewing behavior. We can apply this to an example of such a typical student: *I first watch the movie, and then I try to guess which questions will be asked and then I watch those specific fragments again.* This viewing behavior is strategic in the sense that the student consciously plans at the beginning of a viewing session to list the fragments to be watched again at the end of the video. He also monitors his learning behavior (metacognition). We add this strategic viewing behavior to our two earlier defined viewing styles: *maintenance rehearsal* and *elaboration.* In Table 6.2, we list these viewing styles, as well as the linear viewing style (one-pass scenario) and the zapping viewing style (zapping scenario) from our first experiment.

Table 6.2
Viewing behavior and viewing styles

Viewing style	Viewing behavior
Linear	a student watches a video in one pass (uninterruptedly) from the beginning to the end
Elaboration	a student watches a video again after finishing the first time in one-pass
Maintenance Rehearsal	a student watches parts of a video repeatedly
Zapping	a student skips through the instructional video at intervals of relatively short viewing times
Strategic	a student e.g. watches a video in one pass (uninterruptedly) from the beginning to the end, and then watches one or more specific segments again

We could not find strong correlations between viewing styles and more pervasive traits like learning styles and short-term memory.

Students however proved to be flexible in changing their viewing behavior and this did not lower their test scores. This flexibility of the student in adapting his viewing behavior is in line with the missing correlation between pervasive personality traits and learning styles found earlier in our second experiment and the first part of the third experiment.

Investigated further in the second part of the third experiment was whether learning outcomes can be promoted through raising the awareness of students about their viewing behavior. Based on earlier research of Cook (1991), we made students aware of their viewing behavior to enhance learning effects. Cook made students aware of their learning style by giving them study tips based on the results of a learning style test. She found significantly higher learning effects with these students. We gave student viewing tips about possible other and new viewing behavior, based on their earlier viewing behavior. We also found higher learning effects.

An awareness instruction in the second part of this experiment about their viewing behavior was given to 19 students in an experiment. Their learning outcomes were about 20% higher. This second part has been scaled up to more students in the fourth and last experiment. Furthermore, we wanted to investigate the possible role of the prior knowledge level of a student about the topics covered in the instruction videos on their learning and retention effects. This brought us to the fourth experiment.

The fourth and last research question was: *What is the difference in learning effects and retention decays between students with and without an awareness instruction and what is the effect of the students' level in prior knowledge on the learning effects?*

The differences of our third experiment in learning effects (20% higher) could not be reproduced. Students with middle prior knowledge level benefitted from an awareness instruction on an alternative viewing behavior. However, the other students did not.

An awareness instruction on an alternative viewing behavior increased the viewing repertoire of these students. So we introduced a model based on metacognition and metastyles. We distinguished between students with a narrow viewing repertoire (*one-trick* viewers), students with a broad viewing repertoire (*multi-trick* viewers), and *strategic* viewers. We found that the learning effects of *one-trick viewers* were less than the learning effects of *multi-trick viewers* or *strategic viewers*.

The retention level of students from the awareness group with low prior knowledge decayed stronger than the retention level from students from the non-awareness group. This is an indication that the retention effects are negatively influenced through an awareness instruction about on an alternative viewing behavior for these students with low prior knowledge.

Summary of the research findings

We researched the viewing behavior of students while they were learning from instruction videos. Some behaviors were expected such as the viewing of a video in one pass. We also expected a repetitive behavior because a student has to rewind a video when he does not understand something he is watching for the first time.

We less expected the two-pass behavior because we instructed students to rewind parts of the video which they did not understand and not wait until the end of the video. One of our students said: "*Most of the time I do not rewind a piece of the video immediately because it happens quite often that a specific topic which I want to view again is explained at a later moment in the video*".

Also the zapping behavior of a student was not expected. This brought us to the possible link between viewing behavior and learning styles. This zapping behavior looked similar to the learning behavior of a student with the undirected learning style of Vermunt (1992). This possible link of viewing behavior and learning styles could be quite promising because this would enable us to make learning management systems more personalized.

There have been some nice examples of learning management systems with such an adaptive component based on learning styles. One of them is *eTeacher*. Schiaffino, Garcia, & Amandi (2008) use an agent based on a Bayesian network and the learning style model of Felder & Silverman (1988). For instance: if a student is not linear in his learning patterns than he will be presented a summary at the beginning of a learning task instead of at the end.
We would be able to enhance the information about a student in such a network if we would be able to find a link between viewing behavior and learning styles.

We did not find any clear relation between the more pervasive personality traits such as the learning style model of Felder & Silverman (1988), the short-term memory of students, and the viewing behavior of students. However, we did find that students were flexible in changing their viewing behavior, without lowering their test scores. Also, more than half of the students were watching videos strategically. They watched the video for the first time in one pass and viewed specific parts again which they for instance think will be asked during the test.

Students with some basic knowledge of the topics covered in the videos benefited most from the use of possible other and new viewing behaviors. Students with low prior knowledge benefitted the least. Interesting also was that this knowledge gain disappeared after a few weeks. Knowledge construction seems worse when doing two things at the same time: learning from video and exhibiting new viewing behavior.

We distinguished between students with a narrow viewing repertoire (*one-trick* viewers), students with a broad viewing repertoire (*multi-trick* viewers), and *strategic* viewers. We found that the learning effects of *one-trick viewers* were less than the learning effects of *multi-trick viewers* or *strategic viewers*.

We conclude that interactive video is a modality that can offer added didactical value, in line with the conclusion of Hattie (2009). Some conditions have to be met: the technical and didactical quality of the video has to be good, the integration in a learning task has to be apparent, students have to be aware about their viewing behaviors, teachers have to be aware to enrich the viewing repertoire of students when they have at least some basic knowledge.
When these conditions are met, as in our research setting, learning effects could be raised by 20 % like in our third experiment.

6.2 Theoretical implications of the research findings

The theoretical implications of our research project will be discussed in this section.

Verhagen (1992) researched the optimum length of segments in interactive video programmes. Verhagen defined the maximum number of questions that can be asked about the topics covered in the video programme as the amount of information elements. His research indicates that a maximum segment length of about 22 information elements is appropriate when presenting factual information to university freshmen and up to about 3 minutes of presentation time can be used.

Our instruction video used in the last two experiments had an initial total length of about 8 minutes and 28 information elements, which exceeded the guideline of Verhagen. This supports segmentation of our instruction video in smaller segments with less information elements. In a pretest of our research setting, our students stopped much earlier than three minutes or 22 information elements. Students stopped after about one minute and four information elements. Students in the research of Verhagen indicated that they usually stopped when an episode within a video came to an end. This was also the case with our instruction video when the viewpoint of the camera changed at that point. We suggest adding the guideline "start a new episode when the viewpoint of the video camera changes significantly" as a new and important guideline when segmenting instruction videos.

Felder & Silverman (1988), introduced 32 learning styles embedded in five dimensions: perception, input, organization, processing, and understanding. They further introduced five teaching styles in order to accommodate these learning styles also based on five dimensions: content, presentation, organization, student participation and perspective. Felder & Silverman advocate addressing all possible learning styles in a classroom with all possible teaching styles to some extent.

Some of our students preferred text-based tutorials rather than our video-based materials. This confirms the findings of Felder, stating that watching video is not always a preferred teaching style component for students. This means that students should be able to choose between text and video based learning materials, which was not the case in our research setting.

The theoretical underpinning of the third experiment has been based upon earlier work by Huai (2000), who found a correlation between the learning style and the short-term memory of a student. Learners with a weaker short-term memory need to derive lost elements in short term memory by actively recruiting and elaborating elements from long-term memory. Learners with a holistic style build a much more integrated knowledge structure that pays back in terms of flexible problem solving and a much larger factual repertoire in the long run.

We could not reproduce the same link. Huai did use another test (Pask's Smugglers test) in order to score the learning style on the dimension serial –

global. Graf, Lin, & Kinshuk (2008) used the score on the dimension understanding (serial - global) to measure the serialist - holist learning style when using the ILS test of Felder & Silverman (1988).Possibly this conclusion was not correct which was the reason of our choice of the learning style test.

The fourth experiment (and also the second part of our third experiment) was based upon the work of Cook (1991). She made students aware about their learning style by giving them study tips about their learning behavior after a few weeks. Their learning behavior was based on the test score of a learning style test which was taken after three weeks from a ten weeks course. She found significantly higher learning effects in this experiment when comparing the results to students who were not made aware of their learning style. We did not use study tips based on the student’s learning style but suggestions about possible alternative viewing behavior based upon their previous viewing behavior.

Our results are quite similar to the results of Cook. We also found higher learning effects but only for students with some prior knowledge of the topics at hand (Photography in our case). Students with low prior knowledge benefitted the least.

Another interesting fact is about the research setting of Cook (1991). Students had to undergo a learning style test after three weeks and not at the beginning of the course. At the time of the learning style test students have some basic knowledge of the topics at hand and are more able to apply study tips than with no knowledge of the topics at all. Interesting addition would be to score the knowledge level of a student when taking a learning style test in order to give individual study tips to students. Normally this level is measured in a pre-post test condition to calculate learning effects at the beginning and at the end (but not in between).

Designing adaptive learning environments on the basis of learning styles rests upon the idea that students’ learning styles are stable along time and across learning tasks. Huai (2000) tested this hypothesis and found evidences both in literature and experimental outcomes.

The use of learning styles has also been questioned: they are a simplification of the many dimensions and can hardly explain the essence of individual learning characteristics (Willingham, 2009).

Some of our students switched their viewing behavior based upon their cognitive need and this did not lower their test score. This flexibility of the student in adapting his viewing behavior is in line with the missing correlation between pervasive personality traits and learning styles found earlier in our experiments.

Kozhevnikov (2007) explored trends in cognitive style research that have emerged to examine superordinate cognitive styles (meta styles). It defines the extent to which individuals exhibit flexibility and self-monitoring in their choice of styles. The model we introduced in Chapter 5, which is based on metacognition, could offer a better understanding of viewing and learning behavior of video. It incorporates the fact that students should be challenged to use more than one viewing and learning behavior while learning from video.

6.3 Practical implications of the research findings

In this Section we discuss the practical implications of our research findings for higher education.

The learning process of a student can be visualized as follows (Figure 6.1):
The teacher designs and distributes a learning task with an instruction video (1). A student opens this learning task with the instruction video (2) with an internet browser. The learning task and video (3) are sent through a learning management system (A) and the streaming media server (B). Teachers can give also instructions to a student (5) based on information from the student (6). The servers provide the teachers with information about the use of the video and the learning tasks (4).

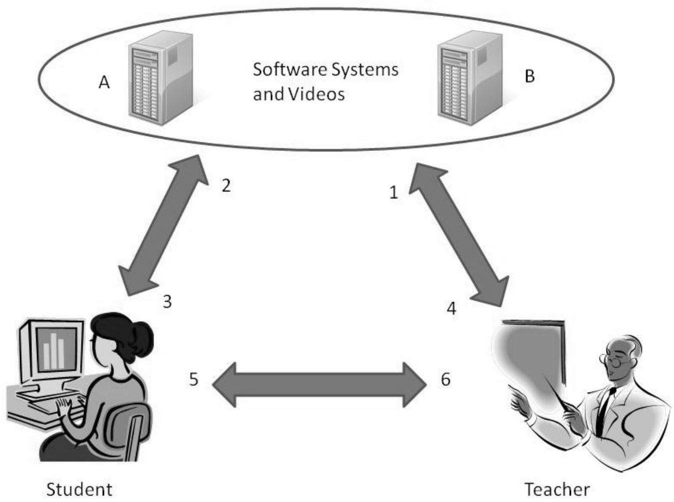

Figure 6.1
The learning process of a student

Practical implications of our research findings can be implemented in four different areas:

1. Teachers
2. Students
3. Software systems (media players and streaming media servers)
4. Video

6.3.1 Teachers

In Section 6.2 we concluded that students should be challenged to use more than one viewing and learning behavior while learning from video in order to enhance their metacognitive skills. Also, it seemed that students, who have a lower prior knowledge of the subject matter, are less able to enhance their metacognitive skills while they are learning from video. Their knowledge construction is worse when doing two things at the same time (multitasking): learning from video and exhibiting new viewing behavior.
Teachers should give viewing tips to students, but not to students with no prior knowledge. This level can be investigated through a pretest at the beginning or intermediate tests during a course. Without this investigation, study advice should not be given at the start of a course where students most likely have no prior knowledge, but after a few lessons.

Some students (in our pilot) indicated that they changed their viewing behavior of the videos after the first test, where they discovered what the exact form of the assignment was. They did not study with emphasis on recall but changed to recognition as soon as they discovered the test was a multiple-choice test. Multiple-choice questions should be used by teachers with great care. In a pre-post-retention setting, where the post test is a multiple choice test and the retention test is an open test, results of the post test may seem high but the retention score could reveal low learning effects.

6.3.2 Students

Students should be made aware of possible alternative viewing behaviors. This could be done through teachers as described in the previous section but also through an (online) instruction video. This video could elaborate about the viewing scenarios, so a student can learn those alternative viewing behaviors. Also, a student should be able to recognize his own viewing behavior in such an instruction video.

Apart from these four viewing scenario's, which are typical for short videos, we also discovered another viewing scenario through the interviews. Viewing behavior that is typical for long instruction videos or materials (in terms of length and information elements) is the switching between assignment and video that we also saw in the fourth experiment. For example, if the video is an instruction of a software program, students will have two programs open at the same time. One is the video player for the instruction video and the other is the software program at hand.

6.3.3 Software systems (media players and streaming media servers)

Some students expressed in interviews that they changed their viewing behavior from strategic to the two-pass approach due to the interaction complexity. Buffering for instance was sometimes a nuisance when searching for a specific element in the video. So in our experiment, both types of viewing behavior sometimes seem to be the same. One of the technical reasons for this buffering of the streaming video server is that we configured it in such a way that buffering on the local client was not possible. We did this to monitor the clicking behavior also in the log files of the server. Under normal conditions, we suggest not to use these settings. The streaming media server needs to be configured in such a way that the media player caches the video content as much as possible.

Media players could also offer the functionality for students to place their own (multiple) markers on the progress bar (Figure 6.2). This way they will not be limited to the use of the mouse as a marker, where they can make only one mark.

Figure 6.2
Media Payer with functionality for students to place their own (multiple) markers on the progress bar

All the links within video that have been discussed so far are internal links. These links refer to starting points in the video itself. External links to other videos could be embedded in the video to help the student with learning from video (Zahn et al., 2004) Building further on their ideas, we suggest making external videos accessible through a list of these external links on the right-hand side of the screen and the internal links on the left-hand side (Figure 6.3). Or vice versa. In this way the need for students to leave the chronological viewing mode will be supported.

Figure 6.3
Media Payer with functionality for internal and external links

Students who demonstrate the multi-trick viewing behavior exhibit more than one viewing behavior. They are expected to use these strategic tools less because switching their viewing behavior can be done with the regular buttons (rewind or play) of the media player.

6.3.4 Video itself

Analyzing the video recordings from the learning process of students, revealed that some students – those with a strategic viewing behavior - used the mouse as a marker on the progress bar to help them to remember the segments to be viewed again. In general, media players could offer more options to help these students with their search for the content they want to view again. E.g. a list of video segments could be presented at the end of the video to give them an opportunity to watch specific segments again. This could be done by linking the starting points of the segments of a video with the progress bar (Figure 6.4). In this figure we used the video segments from our last experiment. Moreover, such a list could also be presented at the start of a video to give an overview of the contents.

Figure 6.4
Segmenting videos for easier navigation for students

Not everyone in education has a positive attitude towards the use of video. Sometimes, a video has been compared to a book but without any structure: without a title page, without an author name, without the number of pages, without chapters and sections, without a table of contents, without an index, etc. The use of such a video (without title, length, segments, etc) in education requires that a student has to watch a video without any idea what he has to do and how long it will take. This is a video with no integration at all with a learning task.

The quality of a video does not need to be perfect but “good enough”. The videos we used in our research were assessed as good, both technical and didactical. One student said that there was no need to view parts of the video again because the topics in the instruction video were explained well.

Bad videos however can be prevented through the use of some guidelines. First of all, the video has to be integrated with a learning task. The purpose of the video should be elaborated in the learning task or in the video itself, together with the optional tests.

Principles of Clark & Mayer (2008) can provide useful guidelines. They discuss several proven guidelines such as the modality- and contiguity principle. The modality principle states that text on screen should also be presented as narrative text. The contiguity principle states that graphics on screen should be closely aligned to corresponding text on screen.

In the case where videos are not didactically good enough, a student has to use the interactive buttons of a media player more often. The use of the strategic tools (Figure 6.2,6.3, and 6.4) could enhance this interaction.

We repeat our suggestion made in Section 6.2 where we suggested adding the guideline “start a new episode when the viewpoint of the video camera changes significantly" as a new and important guideline when segmenting instruction videos.

We can summarize these practical implications with the following advantages and disadvantages for learning from video when using video according to our guidelines. The already know advantages of video like f.i. learning anytime, anyplace, and anywhere will not be repeated. Instead, we will focus on the outcomes of our research and will apply these to our problem statement.

One of the advantages – after implementing our practical implications - will be higher learning effects in the courses where video has been used, possible resulting in less fails and more passes. This can possibly lead to increased output-based annual budgets in higher education and these differences can be used for a more intensified use of video.

Another advantage will be that students - who have been made aware of alternative viewing behaviors - can possibly apply this awareness to other courses as well. Following our research setup we would use this for instructional knowledge but we think for more complex topics this also can be beneficial. Finally, also the awareness of teachers about the learning behavior of students can be used in other courses about instructional knowledge as well.

The disadvantages are financial in nature and involve the costs of developing and organizing these courses for students and teachers. Also, the costs of developing the additions for media players have to be taken into account together with the costs of implementing the guidelines for video.
These costs are once only and are investments. Moreover: budgets will increase annually thus eventually surpassing the investments.

Implementing our practical implications will require a project aimed at the intensified use of video in Higher Education. It incorporates our findings like courses for teachers and students, additions for media players and the integration of video in the learning tasks.

6.4 Reflection on the research setup

In order to measure learning effects a pre-post test was designed. Due to the low number (twelve) of possible questions, a conventional pre-post test could not be used: both tests could only consist of a maximum of six questions. The introduction of a retention test would lower this to four questions.

The (*absolute) learning effect* was defined as the posttest score minus the pretest score. We calculated the prior knowledge (pretest score) by asking the students, directly after the last multiple choice test, which questions they could have answered without watching the corresponding instructional video. In order to measure the posttest score, we used the regular score of the multiple-choice test.

Answering the questions about their pretest score was done well by students. It could be expected that students should be less able in reconstructing their prior knowledge after the test but this was not the case.

After three to four weeks a retention test was taken. It was the same one as the post test. The (*absolute) retention decay* was calculated as the posttest score minus the retention score.
The test was not taken in the same controlled situation as the post test. The test was taken in class and via mail due to organizational circumstances. Repeating our experiment, we would have kept the circumstances for the post and retention test the same: so both in the usability lab or both in class. For our experiment however, the differences were small between the lab and class situations.

Some differences in learning effects were not significant. One possible explanation was that the pre-, post- and retention test lacked sufficient test items. However, increasing the number of test items would also have increased the number of information elements and also the length of the video, thereby possibly exceeding the guidelines of Verhagen (1992) and ourselves. So we kept the length of the video the same.

The topics covered in the instruction videos are on how to use photographic equipment. Assessing learning can be done using multiple-choice tests but we found that using multiple choice questions can influence the viewing behavior of students unexpectedly.
If a student knows the type of test that will be used after watching the video - or more general the learning task - he most likely will adapt his viewing behavior. In the case of open questions – instead of multiple choice tests – his behavior can change from one –pass to two-pass, as some of our students confirmed in interviews. They did the same change of learning behavior when reading textbooks before exams: if the exams were open questions they read the book twice instead of once in the case of a multiple choice test. They studied on recognition instead of recall. In a pilot we didn't instruct the students about the type of tests so they adapted their viewing behavior after the first test. We compensated for this effect by instructing the students before the first test about the type of test.

6.5 Future research

The instruction videos we used in our experiments were only on the knowledge level of the taxonomy of Bloom (Bloom et al., 1956). Learning from video at this knowledge level is more about factual information. We want to repeat the experiments where the topics of the videos are on one of the higher levels of the taxonomy of Bloom (analysis, comprehension, etc).
Learning at a higher and thus more complex level can incorporate the connection of new knowledge presented in the video to existing knowledge. This will possibly require more complex learning tasks which are not linear as the ones we used. We expect that our strategic tools for the media players can be even more useful with these more complex tasks, f.i. when a student wants to watch external videos as part of such a learning task.

We also want to research the appropriate moment for taking a test after a more complex task or video. Tolboom (2012) researched that *immediate* feedback to students seems to be beneficial for procedural knowledge and *delayed* feedback may be useful in cases of more complex (conceptual) tasks. The interaction of a student with a video – pausing etc. - can be seen as a self-induced form of *feedback*: a student does not understand a part of a video and views these difficult parts of the video again.
In general, knowledge tests after a more complex video or learning task should be timed not too early: a student needs time to comprehend the topics covered. Videos on a more complex level most likely will have a longer length than the videos we used, due to the more complex nature of the topics covered and also more questions and more *complex* questions. For very complex tasks the delayed feedback should be given after the instruction; so this means also delaying tests or further tasks, possibly a day after of even longer.

We also want to consider other tests - or organization of the tests - to measure learning effects, especially when the videos are of a more complex nature. Open questions instead of multiple choice questions could be used to reveal more and more significant learning effects, but the automatic and instantaneous grading will not be possible like we did in our experiments. Finally, the use of concept maps could be further investigated as a testing tool.

Our strategic tools for media players proposed in Section 6.3 could also help with knowledge reconstruction when viewing longer videos with more information elements. With the use of standard media players with no strategic help at all, students most likely will remember less when taking tests about the topics covered in the video. Not only the linear knowledge presented in the standard chronological order can be viewed but also branched knowledge presented to the student (internal and external), see Figure 6.2 and Figure 6.3.

Students should not only be instructed about possibly new viewing behavior but also at the right moment. This moment has to do with their prior knowledge: when

this is too low they can find it difficult to learn and apply new viewing behavior as well. Students who have a higher knowledge level can do this more easily.
These instructions about their viewing behavior can be done by teachers but also by coaches who are specialized in metacognition. Teachers nowadays are occupied during lessons in classes with a large number of students. This way they have more time for their own lessons and these coaches can do this more efficiently.

When teachers make their own learning materials, they have to be instructed in a course when they do not possess this knowledge. Most teachers who design nowadays learning tasks for learning environments do not fully use the potential of these environments, especially when the topics will become more complex. Topics of this course can be: the design of better videos, the integration in a learning task, and the design of a test for complex topics.

The possibilities to learn from video have grown both quantitatively and qualitatively. The number of videos that are accessible (f.i. on YouTube) has grown quite significantly. Students can find a lot of videos on a lot of topics that can supplement their learning materials supplied by their institute. Furthermore, the use of rating systems on these videos has had a positive effect on the quality of the videos.
The non-professional use of video creates another problem for teachers. For instance: there are a lot of instruction videos accessible from YouTube about how to learn to play the piano or how to change tires on a bicycle. For these kinds of skills, it becomes natural not to go to regular classes but to learn online firstly. This development can also change learning at higher education: students can prepare themselves which enhances their self-instruction skills. Therefore, when students enter classes their prior knowledge can be much higher than the teacher of these lessons has expected.

Repositories with videos like YouTube can have a lowering effect on the costs of the development of learning materials like video. Sharing the use and co-creation of these videos can improve the quality of these instruction materials.
However, some initiatives in higher education in the Netherlands to facilitate the services around streaming media servers has still not reached fulfilled its promises (Goldschmeding, 2006). One of the reasons is the uncertainty about (digital) rights of videos and another reason is the retrieval of the videos.

Looking further in the future and extrapolating the developments on more intensified use of video and hopefully more repositories could mean that the use of video could be overtaking the use of for instance text books at some point. However, most developments we have seen in comparable areas – like the use of computers and websites - have led to a more blended situation: combining the best of both worlds. This means that text books (or eBooks) will still be used for teachers and students who prefer this kind of modality.

Combining all our suggestions for future research would result in the following research proposal for a PhD student.
Three possible research questions could be:
-What is the influence of the viewing repertoire on learning effects in a classroom?
-How can tools for strategic viewing help to improve these learning effects?
-What is the optimal moment for viewing instructions and tests for students in a classroom?
The first step in this project would involve the creation of some videos based around a more complex topic than simple instruction videos. We would suggest making or choosing videos on three different Bloom levels: knowledge, analysis and comprehension. This would enable the investigation of the right moment of feedback and tests to students, maybe dependent on the Bloom level. Furthermore, we would develop additions to the media players to enhance strategic viewing.

The research setting would be an experiment in a less controlled environment, preferably in a classroom. Two classes should follow a course and one of them should have complex video incorporated in the course and the other regular learning materials. Also, students should perform a pre, post and retention test to measure learning outcomes. Preferably no multiple choice questions but open questions or concept maps. Finally, after a few lessons, the video class should have a viewing test to access their viewing repertoire and make them aware of alternative viewing behaviors. The dependent variable (DV) is the learning effect, the independent variable (IV) the pretest score, and the intervention variable could be the timing of the feedback and the complexity of the topics.

All in all we can say that the right use of video in higher education will lead to higher learning effects, students and teachers that are more aware of their learning and teaching behavior, better videos, and enhanced media players that let users improve their learning from video.

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Summary

This thesis is about learning from video. This research investigates students' viewing behavior while learning from instructive video. Secondly the revealed learning effects were related to the logged browsing sequences. In order to optimize the students' learning effects, an additional intervention that made the students aware of their typical viewing behavior was defined and analyzed for its subsequent effects.

Problem statement

The initial trigger of this research project was the availability of log files from users of video material as nowadays common in education. The patterns in logged viewing sequences allow the researcher to characterize individual viewing behavior and derive his/her learning style.

In higher education, the use of video resources has increased recently. Video modality is seen as attractive as it is associated with the relaxed mood like watching TV. Due to lower success rates, as will be explained below, improving learning from video becomes more and more important because a video – in contrast to a teacher - can be accessed anytime and anywhere. These videos are mostly accessed from a learning management system like Blackboard. These systems are mainly used in order to improve the communication between students and teachers. However, a large portion of a learning management system is only filled with general assignments for students in its native format. Much (personalized) functionality of these learning management systems is therefore not used at all.

At the same time, higher education in many countries (incl. the Netherlands) has become more competence-oriented. The amount of lessons has been reduced while students have to spend more time studying with (digital) materials on their own. These two developments did not lead to higher success rates in higher education. Moreover, the last years there is a tendency to even lower success rates. Half of the students do not finish the first year of their courses and the rest finishes it a few years later as planned.

Most of the projects that aim at higher success rates focus their attention on the scheduled lessons for students. Another way to improve the success rate of higher education is the use of video.
Video nowadays is increasingly used as an instructional tool in education. Students are instructed to enhance their individual learning skills from text rather than from video. Interacting with the control buttons of a media player provides students only with standard tools to interact (start, pause, and stop) with video and does not necessarily support the individual learning process. Therefore it becomes important to optimize the learning process of students from video.

Streaming video servers are nowadays frequently used to distribute video to students. These servers are logging event queues (pausing, rewinding, etc) in so-called log files. Just as in e-business, log files can be used for personalization and evaluation. In educational settings however, mining log files to gather more insight in viewing and learning patterns of students has hardly been employed. Log files are mainly used for detecting errors in the infrastructure and will be deleted as quickly as possible as they may reduce overall system performance. If the viewing behavior of a student potentially influences his or her learning outcomes, we can also use these loggings for personalized feedback to the student.

The need to improve the effectiveness of learning by using video lessons therefore becomes more urgent as web-based materials contain more and more videos and also more and more control tools for the learner. The web has created a much more autonomous and flexible student attitude. If we want to improve the sequential aspect of students' learning from video, it is inevitable to typify and understand how students differ in their learning preferences.

The experiments as described in this thesis are part of a research project with the goal to gain more insight in the learning and viewing patterns of students from video. This understanding aims at the development of videos with a higher learning effect, a more adequate control for the user as a learner and finally a better integration of video in education.

The following problem statement has been formulated at the start of our research project:
What are the characteristics of a framework for an e-learning environment that offers real-time adaptive responses students' individual learning style?

Research questions and methods

This research thesis performed four experiments and resulted in four subsequent journal articles (Table 1).

The following four research questions have been formulated during the research project:

1. Which viewing scenarios can be recognized in log files from streaming media servers?
Learning management systems log data from students while they are logged in to the system. However, no data of the viewing session from a student is logged. Streaming media servers log a lot more data of this viewing session. Not only the session length is recorded but also interaction events of a student with a video like pausing and rewinding.
In the first experiment as described in Chapter 2, the logged viewing patterns of 50 students and twelve instruction videos were analyzed in an explorative research. Four scenarios were recognized:

- the *one-pass* scenario, where a student watches a video in one-pass (uninterruptedly) from the beginning to the end
- the *two-pass* scenario, where a student watches a video again after finishing the first time in one-pass
- the *repetitive* scenario, where a student watches parts of a video repeatedly
- the *zapping* scenario, where a student skips through an instructional video at intervals of relatively short viewing times.

The viewing behavior of the *zapping* scenario is similar to the learning behavior of a student with an *undirected* learning style from Vermunt (1992). According to Blijleven (2005), a broken link between the learning task and learning process could be the underlying factor of this zapping behavior. Furthermore, if we want to make learning management systems more personalized we might use this learning style of a student. Therefore, learning processes and its possible link with learning styles were investigated further in the second experiment.

2. Can we use log files from streaming media servers in order to determine learning processes from students and is there a link with the learning style model from Vermunt?
In the second experiment as described in Chapter 3, the viewing behavior of students was recorded in a controlled environment (usability lab). The log files from streaming media servers were analyzed and semi-structured interviews were held with the students after the learning task.
It demonstrated that students' learning processes could be monitored through the use of log files. However, there was no clear link between viewing scenarios of

students and its underlying learning style. Vermunt's distinction of learning styles not only includes a cognitive- but also a self-regulating and a motivational perspective. Therefore, our focus changed from learning styles to more pervasive personality traits like cognitive styles and the short-term memory of students. This brought us to the third experiment.

3a. Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory?
The third experiment as described in Chapter 4 consists of two parts. The first part (3a) focused on the cognitive perspective and investigates whether the students' viewing behavior is determined by pervasive personality traits. The second part (3b) focused on the awareness about viewing styles.
The students' viewing behaviors were investigated in a controlled environment (usability lab). Semi-structured interviews were taken from the students after they performed the learning task.
This experiment showed that viewing behavior with streaming video of students is not strongly correlated with the more pervasive personal traits such as short-term memory capacity and learning styles (style-oriented). Students however proved to be flexible in changing their viewing behavior.
3b. Can viewing style awareness contribute to higher learning outcomes? An awareness instruction in the second part about their viewing behavior was given to 19 students in an experiment and this enhanced their learning outcomes. Both parts of this third experiment (3a and 3b) have been published in one article (Chapter 4).
This second part (3b) of the third experiment has been up scaled-up in terms of more students in the fourth experiment. Furthermore, the possible role of students' prior knowledge on the topics was investigated in terms of revealed learning effects. This brought us to the fourth experiment.

4. *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*
The fourth experiment (described in Chapter 5) also proposes a new model that addresses both style and strategic elements in the manifest viewing behavior of the student. The model was based on metacognition and recent notions about the use of learning styles in education. The model was applied on a group of 115 students (including the 19 students from the previous experiment) in order to see whether learning effects differ among students with narrow or broad repertoires of viewing behaviors.
Students who demonstrated only one viewing behavior attained lower learning effects than students with multiple viewing behaviors. Also, students who demonstrated a strategic viewing approach attained higher learning effects. They watched the video for the first time in one pass and viewed specific parts again which they for instance think will be asked during the test. However, students with low prior knowledge of the topics proved to enhance their metacognitive skills less.

Furthermore, some students developed marking techniques with the mouse in the media player to watch video more strategically.

During the four experiments we used the following research methods:

- Questionnaires for the first experiment
- Explorative analysis of the log files for the first and second experiment
- Observations in class room for the second experiment
- Semi-structured interviews with students for the last three experiments
- Qualitative analysis of video recordings of students from a usability lab, also for the last three experiments

The second part of the title of this thesis (*viewing behavior of students*) has two meanings. The first one is about the viewing behavior of students. The second one is about our analysis of the video recordings in a usability lab: we were viewing the behavior of students.

The methods are described in more detail in the following chapters and appendices.

The four articles – each presenting one experiment - will be presented in Chapters 2, 3, 4, and 5. The discussion (Chapter 6) presents and summarizes all relevant results from the four experiments. Furthermore, we discuss the theoretical and practical implications of our research findings. Finally, we reflect on our research setup and discuss the needed further research.

Table 1: Thesis structure

Chapter:	**Main conclusions:**
Chapter 1 Introduction Problem statement, research questions, and thesis structure	
Chapter 2 How to interpret viewing scenarios in log files from streaming media servers Research question: *Which viewing scenarios can be recognized in log files from streaming media servers?*	Four viewing scenarios were recognized: one-pass, repetitive, two-pass, and a zapping scenario.
Chapter 3 How to use log files from streaming media servers to determine learning processes Research question: *Can we use log files from streaming media servers to determine learning processes from students, and is there a link with the learning style model from Vermunt?*	Students' learning processes could be monitored through the use of log files. However, there is no clear link between viewing scenarios of students and their learning style.
Chapter 4 Using learning styles and viewing styles in streaming video Research question: *Do viewing styles go together with pervasive personality traits such as manifested learning styles and short-term memory and can viewing style awareness contribute higher learning outcomes?*	Viewing behavior with streaming video of students is not strongly correlated to short-term memory capacity and learning styles. Students are flexible in changing their viewing behavior. An awareness instruction enhanced their learning outcomes.
Chapter 5 Viewing video for learning Research question: *What is the difference in learning effects and retention decays between students with and without an awareness instruction on an alternative viewing behavior and what is the effect of the students' level in prior knowledge on the learning effects?*	Students who demonstrate a strategic or a multiple viewing approach attain higher learning effects than students with only one viewing approach. Students with low prior knowledge of the topics are less able to enhance their metacognitive skills. Some students develop marking techniques with the mouse in the media player to watch video more strategically.
Chapter 6 Discussion Findings, implications, reflection, and future work	

Most relevant findings of the experiments

We researched the viewing behavior of students while they were learning from instruction videos. Some behaviors were expected such as the viewing of a video in one pass. We also expected a repetitive behavior because a student has to rewind a video when he does not understand something he is watching for the first time.

We less expected the two-pass behavior because we instructed students to rewind parts of the video which they did not understand and not wait until the end of the video. One of our students said: "*Most of the time I do not rewind a piece of the video immediately because it happens quite often that a specific topic which I want to view again is explained at a later moment in the video"*.

Also the zapping behavior of a student was not expected. This brought us to the possible link between viewing behavior and learning styles. This zapping behavior looked similar to the learning behavior of a student with the undirected learning style of Vermunt (1992). This possible link of viewing behavior and learning styles could be quite promising because this would enable us to make learning management systems more personalized.

There have been some nice examples in literature of learning management systems with such an adaptive component based on learning styles. One of them is *eTeacher*. Schiaffino, Garcia, & Amandi (2008) use an agent based on a Bayesian network and the learning style model of Felder & Silverman (1988). For instance: if a student is not linear in his learning patterns than he will be presented a summary at the beginning of a learning task instead of at the end. We would be able to enhance the information about a student in such a network if we would be able to find a link between viewing behavior and learning styles.

We did not find any clear relation between the more pervasive personality traits such as the learning style model of Felder & Silverman (1988), the short-term memory of students, and the viewing behavior of students. However, we did find that students were flexible in changing their viewing behavior, without lowering their test scores. Also, more than half of the students were watching videos strategically.

Students with some basic knowledge of the topics covered in the videos benefited most from the use of possible other and new viewing behaviors. Students with low prior knowledge benefitted the least. Interesting also was that this knowledge gain disappeared after a few weeks. Knowledge construction seems worse when doing two things at the same time: learning from video and exhibiting new viewing behavior.

We distinguished between students with a narrow viewing repertoire (*one-trick* viewers), students with a broad viewing repertoire (*multi-trick* viewers), and *strategic* viewers. We found that the learning effects of *one-trick viewers* were less than the learning effects of *multi-trick viewers* or *strategic viewers*.

We conclude that interactive video is a modality that can offer added didactical value, in line with the conclusion of Hattie (2009). Some conditions have to be met: the technical and didactical quality of the video has to be good, the integration in a learning task has to be apparent, students have to be aware about their viewing behaviors, teachers have to be aware to enrich the viewing repertoire of students when they have at least some basic knowledge.
When these conditions are met, as in our research setting, learning effects could be raised by 20 % like in our third experiment.

Theoretical implications of the research findings

The theoretical underpinning of the third experiment has been based upon earlier work by Huai (2000), who found a correlation between the learning style and the short-term memory of a student. She signaled a parallel between the students' learning style and his/her short-term memory capacity. Learners with a weaker short-term memory and a holistic style need to derive lost elements in short term memory by actively recruiting and elaborating elements from long-term memory. Learners with such a holistic style build a much more integrated knowledge structure that pays back in terms of flexible problem solving and a much larger factual repertoire in the long run.
We could not reproduce the same link. Huai did use another test (Pask's Smugglers test) in order to score the learning style on the dimension serial – global. Graf, Lin, & Kinshuk (2008) used the score on the dimension *understanding* to measure the learning style of a student when using the learning style test of Felder & Silverman (1988).Possibly this conclusion was not correct, which was the reason of our choice of the learning style test.

The fourth experiment (and also the second part of our third experiment) was based upon the work of Cook (1991). She made students aware about their learning style by giving them study tips about their learning behavior after a few weeks. Their learning behavior was based on the test score of a learning style test which was taken after three weeks from a ten weeks course. She found significantly higher learning effects in this experiment when comparing the results to students who were not made aware of their learning style. We did not use study tips based on the student's learning style but suggestions about possible alternative viewing behavior based upon their previous viewing behavior.
Our results are quite similar to the results of Cook. We also found higher learning effects but only for students with some prior knowledge of the topics at hand (Photography in our case). Students with low prior knowledge benefitted the least.

Another interesting fact is about the research setting of Cook (1991). Students had to undergo a learning style test after three weeks and not at the beginning of the course. At the time of the learning style test students have some basic knowledge of the topics at hand and are more able to apply study tips than with no knowledge of the topics at all. Interesting addition would be to score the knowledge level of a student when taking a learning style test in order to give individual study tips to students. Normally this level is measured in a pre-post test condition to calculate learning effects at the beginning and at the end (but not in between).

Designing adaptive learning environments on the basis of learning styles rests upon the idea that students' learning styles are stable along time and across learning tasks. The use of learning styles has also been questioned: they are a simplification of the many dimensions and can hardly explain the essence of individual learning characteristics (Willingham, 2009).

Some of our students switched their viewing behavior based upon their cognitive need and this did not lower their test score. This flexibility of the student in adapting his viewing behavior is in line with the missing correlation between pervasive personality traits and learning styles found earlier in our experiments.

Kozhevnikov (2007) explored trends in cognitive style research that have emerged to examine superordinate cognitive styles (meta styles). It defines the extent to which individuals exhibit flexibility and self-monitoring in their choice of styles. The model we introduced in Chapter 5, which is based on metacognition, could offer a better understanding of viewing and learning behavior of video. It incorporates the fact that students should be challenged to use more than one viewing and learning behavior while learning from video.

Practical implications of the research findings

The learning process of a student can be visualized as follows (Figure 1):
The teacher designs and distributes a learning task with an instruction video (1). A student opens this learning task with the instruction video (2) with an internet browser. The learning task and video (3) is sent through a learning management system (A) and the streaming media server (B). Teachers can give also instructions to a student (5) based on information from the student (6). The servers provide the teachers with information about the use of the video and the learning tasks (4).

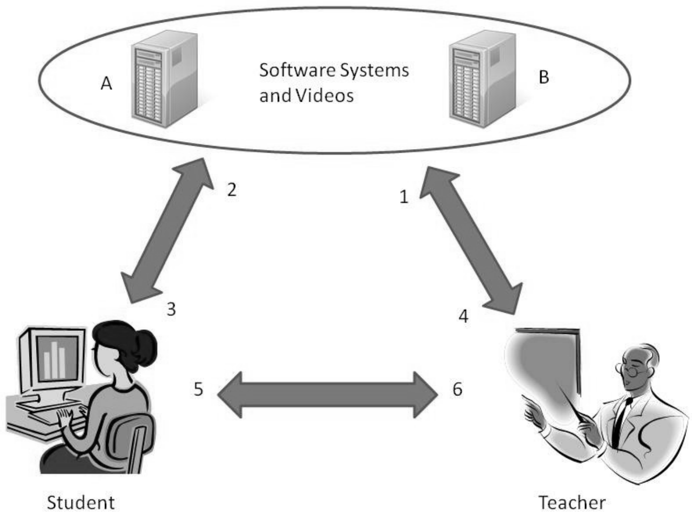


Figure 1
The learning process of a student

The practical implications of our research findings can be implemented in four different areas:

1. *Teachers*
   We concluded that students should be challenged to use more than one viewing and learning behavior while learning from video in order to enhance their metacognitive skills. Also, it seemed that students, who have a lower prior knowledge of the subject matter, are less able to enhance their metacognitive skills while they are learning from video. Their knowledge construction is worse when doing two things at the same time

(multitasking): learning from video and exhibiting new viewing behavior. Teachers should give viewing tips to students, but not to students with no prior knowledge. This level can be investigated through a pretest at the beginning or intermediate tests during a course. Without this investigation, study advice should not be given at the start of a course where students most likely have no prior knowledge, but after a few lessons.

2. *Students*
   Students should be made aware of possible alternative viewing behaviors. This could be done through teachers as described in the previous section but also through an (online) instruction video. This video could elaborate about the viewing scenarios, so a student can learn those alternative viewing behaviors. Also, a student should be able to recognize his own viewing behavior in such an instruction video.

3. *Software systems (media players and streaming media servers)*
   Media players could also offer the functionality for students to place their own (multiple) markers on the progress bar (Figure 2). This way they will not be limited to the use of the mouse as a marker, where they can make only one mark.
   All the links within video that have been discussed so far are internal links. These links refer to starting points in the video itself. External links to other videos could be embedded in the video to help the student with learning from video (Zahn et al., 2004) Building further on their ideas, we suggest making external videos accessible through a list of these external links on the right-hand side of the screen and the internal links on the left-hand side (Figure 3). Or vice versa. In this way the need for students to leave the chronological viewing mode will be supported.

4. *Video itself (located on the streaming media server)*
   Analyzing the video recordings from the learning process of students, revealed that some students – those with a strategic viewing behavior - used the mouse as a marker on the progress bar to help them to remember the segments to be viewed again. In general, media players could offer more options to help these students with their search for the content they want to view again. E.g. a list of video segments could be presented at the end of the video to give them an opportunity to watch specific segments again. This could be done by linking the starting points of the segments of a video with the progress bar (Figure 4). In this figure we used the video segments from our last experiment. Moreover, such a list could also be presented at the start of a video to give an overview of the contents.
   Not everyone in education has a positive attitude towards the use of video. Sometimes, a video has been compared to a book but without any structure: without a title page, without an author name, without the number of pages, without chapters and sections, without a table of contents,

without an index, etc. The use of such a video (without title, length, segments, etc) in education requires that a student has to watch a video without any idea what he has to do and how long it will take. This is a video with no integration at all with a learning task.
The quality of a video does not need to be perfect but “good enough”. The videos we used in our research were assessed as good, both technical and didactical. One student said that there was no need to view parts of the video again because the topics in the instruction video were explained well. Bad videos however can be prevented through the use of some guidelines. First of all, the video has to be integrated with a learning task. The purpose of the video should be elaborated in the learning task or in the video itself, together with the optional tests.
In the case where videos are not didactically good enough, a student has to use the interactive buttons of a media player more often. The use of the strategic tools (Figure 2,3, and 4) could enhance this interaction. .

Figure 2
Media Player with functionality for students to place their own (multiple) markers on the progress bar

Figure 3
Media Player with functionality for internal and external links

Figure 4
Segmenting videos for easier navigation for students

One of the advantages – after implementing our practical implications - will be higher learning effects in the courses where video has been used, possible resulting in less fails and more passes. This can possibly lead to increased output-based annual budgets in higher education and these differences can be used for a more intensified use of video.
Another advantage will be that students - who have been made aware of alternative viewing behaviors - can possibly apply this awareness to other courses as well. Following our research setup we would use this for instructional knowledge but we think for more complex topics this also can be beneficial.
Finally, also the awareness of teachers about the learning behavior of students can be used in other courses about instructional knowledge as well.

The disadvantages are financial in nature and involve the costs of developing and organizing these courses for students and teachers. Also, the costs of developing the additions for media players have to be taken into account together with the costs of implementing the guidelines for video.
These costs are once only and are investments. Moreover: budgets will increase annually thus eventually surpassing the investments.

Implementing our practical implications will require a project aimed at the intensified use of video in Higher Education. It incorporates our findings like courses for teachers and students, additions for media players and the integration of video in the learning tasks.

Reflection on the research setup

In order to measure learning effects a pre-post-retention test was designed. Due to the low number (twelve) of possible questions, a conventional pre-post test could not be used: both tests could only consist of a maximum of six questions. The introduction of a retention test would lower this to four questions.

The (*absolute) learning effect* was defined as the posttest score minus the pretest score. We calculated the prior knowledge (pretest score) by asking the students, directly after the last multiple choice test, which questions they could have answered without watching the corresponding instructional video. In order to measure the posttest score, we used the regular score of the multiple-choice test. Answering the questions about their pretest score was done well by students. It could be expected that students should be less able in reconstructing their prior knowledge after the test but this was not the case.

Some differences in learning effects were not significant. One possible explanation was that the pre-, post- and retention test lacked sufficient test items. However, increasing the number of test items would also have increased the number of information elements and also the length of the video, thereby possibly exceeding the guidelines of Verhagen (1992) and ourselves. So we kept the length of the video the same.

Future research

The instruction videos we used in our experiments were only on the knowledge level of the taxonomy of Bloom (Bloom et al., 1956). Learning from video at this knowledge level is more about factual information. We want to repeat the experiments where the topics of the videos are on one of the higher levels of the taxonomy of Bloom (analysis, comprehension, etc).
Learning at a higher and thus more complex level can incorporate the connection of new knowledge presented in the video to existing knowledge. This will possibly require more complex learning tasks which are not linear as the ones we used. We expect that our strategic tools for the media players can be even more useful with these more complex tasks, f.i. when a student wants to watch external videos as part of such a learning task.

We also want to research the appropriate moment for taking a test after a more complex task or video. Tolboom (2012) researched that *immediate* feedback to students seems to be beneficial for procedural knowledge and *delayed* feedback may be useful in cases of more complex (conceptual) tasks. The interaction of a student with a video – pausing etc. - can be seen as a self-induced form of *feedback*: a student does not understand a part of a video and views these difficult parts of the video again.
In general, knowledge tests after a more complex video or learning task should be timed not too early: a student needs time to comprehend the topics covered. Videos on a more complex level most likely will have a longer length than the videos we used, due to the more complex nature of the topics covered and also more questions and more *complex* questions. For very complex tasks the delayed feedback should be given after the instruction; so this means also delaying tests or further tasks, possibly a day after of even longer.

We also want to consider other tests - or organization of the tests - to measure learning effects, especially when the videos are of a more complex nature. Open questions instead of multiple choice questions could be used to reveal more and more significant learning effects, but the automatic and instantaneous grading will not be possible like we did in our experiments. Finally, the use of concept maps could be further investigated as a testing tool.

Students should not only be instructed about possibly new viewing behavior but also at the right moment. This moment has to do with their prior knowledge: when this is too low they can find it difficult to learn and apply new viewing behavior as well. Students who have a higher knowledge level can do this more easily.
These instructions about their viewing behavior can be done by teachers but also by coaches who are specialized in metacognition. Teachers nowadays are occupied during lessons in classes with a large number of students. This way they

have more time for their own lessons and these coaches can do this more efficiently.

Combining all our suggestions for future research would result in the following research proposal for a PhD student.
Three possible research questions could be:
-What is the influence of the viewing repertoire on learning effects in a classroom?
-How can tools for strategic viewing help to improve these learning effects?
-What is the optimal moment for viewing instructions and tests for students in a classroom?
The first step in this project would involve the creation of some videos based around a more complex topic than simple instruction videos. We would suggest making or choosing videos on three different Bloom levels: knowledge, analysis and comprehension. This would enable the investigation of the right moment of feedback and tests to students, maybe dependent on the Bloom level. Furthermore, we would develop additions to the media players to enhance strategic viewing.

The research setting would be an experiment in a less controlled environment, preferably in a classroom. Two classes should follow a course and one of them should have complex video incorporated in the course and the other regular learning materials. Also, students should perform a pre, post and retention test to measure learning outcomes. Preferably no multiple choice questions but open questions or concept maps. Finally, after a few lessons, the video class should have a viewing test to access their viewing repertoire and make them aware of alternative viewing behaviors. The dependent variable (DV) is the learning effect, the independent variable (IV) the pretest score, and the intervention variable could be the timing of the feedback and the complexity of the topics.

All in all we can say that the right use of video in higher education will lead to higher learning effects, students and teachers that are more aware of their learning and teaching behavior, better videos, and enhanced media players that let users improve their learning from video.

Samenvatting

Dit proefschrift gaat over het leren van video. Onderzocht werd het kijkgedrag van studenten, terwijl ze leerden van instructievideo's. Vervolgens werden de leereffecten gerelateerd aan het gelogde surfgedrag. Om de leereffecten van studenten te optimaliseren, werd een extra interventie gedefinieerd die studenten bewust maakte van hun kijkgedrag en de resultaten werden geanalyseerd op de daaropvolgende effecten.

Probleemstelling

De eerste aanleiding voor dit onderzoeksproject was de beschikbaarheid van log files van gebruikers van video's zoals die tegenwoordig worden ingezet in het onderwijs. De patronen in de gelogde kijksequenties stellen je als onderzoeker in staat om het kijkgedrag te karakteriseren en mogelijk zijn of haar leerstijl hieruit af te leiden.

In het hoger onderwijs is het gebruik van videomateriaal recent toegenomen. Video als modaliteit wordt gezien als attractief, omdat het geassocieerd wordt met een ontspannen houding zoals het kijken naar TV. Door lagere slagingspercentages, zoals verderop zal worden uitgelegd, wordt het verbeteren van het leren van video steeds belangrijker, omdat video – in tegenstelling tot een leraar – plaats en tijdonafhankelijk kan worden ingezet. Deze video's worden meestal ontsloten vanuit een leermanagementsysteem zoals Blackboard. Deze systemen worden meestal gebruikt om de communicatie tussen studenten en docenten te verbeteren. Echter, een groot deel van deze leeromgevingen wordt slechts gevuld met algemene opdrachten in het oorspronkelijke bestandsformaat voor studenten. Veel (gepersonaliseerde) functionaliteiten van deze systemen worden dus helemaal niet gebruikt.

Tegelijkertijd wordt het hoger onderwijs in veel landen (inclusief Nederland) steeds meer competentiegericht. Het aantal lessen is verminderd, terwijl de studenten meer tijd zelfstandig besteden aan het bestuderen van (digitale) materialen. Deze twee ontwikkelingen hebben niet geleid tot hogere slagingspercentages in het hoger onderwijs. Bovendien is er de laatste jaren een tendens naar nog lagere slagingspercentages. De helft van de studenten maakt het eerste jaar van hun studie vaak niet af en de rest rondt de studie een paar jaar later dan gepland af.

Het merendeel van de projecten die gericht zijn op hogere slagingspercentages richt de aandacht vooral op een hoger aantal geplande lessen voor studenten. Een andere manier om het succes van het hoger onderwijs te verbeteren is het gebruik van video. Video wordt tegenwoordig steeds meer gebruikt als leermiddel in het onderwijs. Studenten worden wel geïnstrueerd om hun eigen vaardigheden te vergroten om te leren van teksten, maar niet van video. Interactie via de bedieningsknoppen van een media speler geeft studenten alleen maar standaard opties (start, pauze en stop) en ondersteunt niet het individuele leerproces. Daarom wordt het steeds belangrijker om het leerproces van studenten van video te optimaliseren.

Streaming video servers worden tegenwoordig vaak gebruikt om video's te distribueren naar studenten. Deze servers loggen events (pauzeren, terugspoelen, etc.) in zogenaamde log files. Net zoals in e-business kunnen log files gebruikt worden voor personalisatie en evaluatie. Echter, in educatieve omgevingen wordt het onderzoeken van log files om zo meer inzicht te krijgen in kijk- en leerpatronen amper ingezet. Log files worden vooral gebruikt voor het detecteren van fouten in de infrastructuur en worden daarna zo snel mogelijk verwijderd, omdat ze de algehele systeemprestaties verminderen. Als het kijkgedrag van een student mogelijk zijn leeruitkomsten beïnvloedt, kunnen we deze log files gebruiken voor gepersonaliseerde feedback naar de student.

De noodzaak om de effectiviteit van het leren te verbeteren door het gebruik van videolessen wordt nog meer verhoogd, omdat webgebaseerde lesmaterialen steeds meer controle-instrumenten voor de leerling bevatten en steeds meer video's. Het web heeft een veel meer autonome en flexibele student gecreëerd. Willen we alle aspecten van het leerproces van leerlingen van video verbeteren, is het onvermijdelijk te leren begrijpen hoe studenten verschillen in hun voorkeuren.

De experimenten, zoals beschreven in dit proefschrift, zijn onderdeel van een promotieonderzoek dat tot doel heeft om meer inzicht te krijgen in de leer- en kijkpatronen van studenten van video. Deze inzichten kunnen bijdragen aan de ontwikkeling van video's met hogere leereffecten, aan meer controle over het leerproces van de student en aan een betere integratie van video in het onderwijs.

De volgende probleemstelling is daarom geformuleerd bij de start van het promotieonderzoek:
Wat zijn de karakteristieken van een framework voor een e-learning omgeving die in real-time adaptief is, gebaseerd op de individuele leerstijl van een student?

Onderzoeksvragen en methoden

Dit promotieonderzoek bestond uit vier experimenten en resulteerde in vier journal publicaties (Tabel 1).

De volgende vier onderzoeksvragen zijn geformuleerd tijdens het promotieonderzoek:

1. Welke kijkscenario's kunnen herkend worden in de log files van streaming media servers?
Leermanagementsystemen loggen data van studenten, terwijl ze ingelogd zijn in het systeem. Echter, van de kijksessie van een student worden geen data gelogd. Streaming media servers loggen veel meer data van een kijksessie van een student dan een leermanagementsysteem. Niet alleen wordt de lengte van de sessie vastgelegd, maar ook de interactie van een student met een video, zoals pauzeren en terugspoelen. In het eerste experiment, zoals beschreven is in hoofdstuk 2, zijn de gelogde kijkpatronen van 50 studenten en twaalf instructievideo's geanalyseerd in een exploratief onderzoek.

Vier scenario's zijn herkend:

- het *one-pass* scenario, waarbij een student de video in één keer afkijkt,
- het *repetitive* scenario, waarbij een student een deel van de video terugspoelt dat hij niet begrepen heeft,
- het *two-pass* scenario, waarbij een de student de video nog een keer bekijkt, nadat hij de video in één keer heeft bekeken tijdens de eerste keer,
- het *zapping* scenario, waarbij een student door een video springt met relatief korte kijktijden.

Het kijkgedrag van het zapping scenario is vergelijkbaar met het leergedrag van een student met de *ongerichte* leerstijl van Vermunt (1992). Volgens Blijleven (2005) kan een breuk tussen de leertaak en het leerproces de achterliggende factor zijn van dit zapgedrag. Willen we leeromgevingen meer gepersonaliseerd maken dan zouden we deze leerstijl van een student kunnen gebruiken. In het tweede en volgende experiment zijn de leerprocessen en de mogelijke link met leerstijlen verder onderzocht.

2. Kunnen we log files van streaming media servers gebruiken om de leerprocessen van studenten vast te stellen en is er een link met het leerstijlmodel van Vermunt?
In het tweede experiment, zoals beschreven in hoofdstuk 3, werd het kijkgedrag van studenten opgenomen in een gecontroleerde omgeving (usability lab). De log files van de streaming media servers werden geanalyseerd en er werden semi-gestructureerde interviews afgenomen aan de studenten na afloop van de leertaak.

Het bleek dat het leerproces van de student kon worden gemonitord door gebruik te maken van log files. Echter, er bleek geen duidelijk verband te zijn tussen de kijkscenario's van studenten en hun leerstijl. Vermunts onderverdeling van leerstijlen bevat niet alleen een cognitief aspect, maar ook een zelfregulatie- en motivatieaspect. Hierdoor verschoof onze focus van leerstijlen naar meer pervasieve persoonlijkheidskenmerken, zoals cognitieve stijlen en het kortetermijngeheugen van studenten. Dit bracht ons op het derde experiment.

3a. Hangen kijkstijlen ook samen met persoonlijkheidskenmerken, zoals gemanifesteerde leerstijlen en het kortetermijngeheugen?
Het derde experiment, zoals beschreven in hoofdstuk 4, bestaat uit twee delen. Het eerste deel (3a) focust op het cognitieve aspect en onderzoekt of het kijkgedrag van studenten ook samenhangt met hun pervasieve persoonlijkheidskenmerken. Het tweede deel (3b) focust op het zich bewust zijn van hun kijkstijl.

Het kijkgedrag van studenten werd onderzocht in een gecontroleerde omgeving (usability lab). Er werden semi-gestructureerde interviews afgenomen bij studenten, nadat zij de leertaak hadden voltooid.

Dit experiment laat zien dat kijkgedrag van studenten niet sterk gecorreleerd is met de pervasieve persoonlijkheidskenmerken, zoals kortetermijngeheugen en hun leerstijl. Echter, studenten zijn wel flexibel in het veranderen van hun kijkgedrag.

3b. Kan het zich bewust zijn van het kijkgedrag bijdragen aan hogere leeruitkomsten?

Een instructie over het zich bewust zijn van het kijkgedrag van een student werd gegeven aan negentien studenten in een experiment en dit verhoogde hun leeruitkomsten. Beide delen van dit experiment (3a en 3b) zijn gepubliceerd in een artikel (hoofdstuk 4).

Dit tweede deel (3b) van het derde experiment werd opgeschaald naar meer studenten in het vierde experiment. Verder werd ook de mogelijke rol van de voorkennis van een student onderzocht in termen van leereffecten. Dit bracht ons op het vierde experiment

4. Wat is het verschil in leereffecten (en retentieafname) tussen studenten mét en zonder een instructie over het zich bewust zijn van alternatief kijkgedrag en wat is het effect van het niveau in voorkennis op leereffecten?

Het vierde experiment (beschreven in hoofdstuk 5) stelt ook een nieuw model voor die zowel stijl- als strategische elementen beschrijft. Het model is gebaseerd op metacognitie en recente opvattingen over het inzetten van leerstijlen in het onderwijs. Het model is gebruikt bij een groep van 115 studenten (inclusief de negentien studenten uit het vorige experiment) om te kijken in hoeverre er verschillen zijn tussen studenten met een breed en smal kijkrepertoire in kijkgedrag.

Studenten met slechts één soort kijkgedrag bereikten lagere leereffecten dan studenten met meer soorten kijkgedrag.

Ook studenten met een strategische kijkaanpak bereikten hogere leereffecten. Ze keken de video voor de eerste keer in one-pass en bekeken specifieke delen, waarover zij dachten vragen te zullen krijgen, opnieuw tijdens de test.
Echter, studenten met een lage voorkennis van de onderwerpen lieten minder vooruitgang van hun metacognitieve vaardigheden zien dan studenten met een hoge voorkennis.
Verder ontwikkelden studenten markeringstechnieken met de muis in de media speler om zo video's meer strategisch te bekijken.

Tijdens de vier experimenten hebben we de volgende onderzoeksmethoden gebruikt:

- Vragenlijsten voor het eerste experiment
- Exploratieve analyse van de log files voor het eerste en tweede experiment
- Observaties in het klaslokaal voor het tweede experiment
- Semi-gestructureerde interviews met studenten voor de laatste drie experimenten
- Kwalitatieve analyse van de video-opnames met studenten uit het usability lab, ook voor de laatste drie experimenten

Het tweede deel van de Engelse titel van dit proefschrift (*viewing behavior of students)* heeft twee betekenissen. De eerste betekenis gaat over het kijkgedrag van studenten zelf. De tweede betekenis gaat over onze analyse van de video-opnames in het usability lab: we keken dus ook zelf naar het kijkgedrag van studenten.

De methoden zijn in meer detail beschreven in de volgende hoofdstukken en in de appendix.

De vier artikelen, die elk overeenkomen met een experiment, worden gepresenteerd in hoofdstukken 2, 3, 4 en 5. De discussie (hoofdstuk 6) vat alle relevante resultaten samen van de vier experimenten. Verder zullen we de theoretische en praktische implicaties van de onderzoeksresultaten laten zien. Tot slot zullen we onze onderzoeksopzet evalueren en toekomstig onderzoek bediscussiëren.

Tabel 1: Structuur van het proefschrift

Hoofdstuk:	**Belangrijkste conclusies**
Hoofdstuk 1 Introduction Probleemstelling, onderzoeksvragen en de structuur van het proefschrift	
Hoofdstuk 2 How to interpret viewing scenarios in log files from streaming media servers Onderzoeksvraag: *Welke kijkscenario's kunnen herkend worden in de log files van streaming media servers?*	Vier kijkscenario's zijn herkend: one-pass, repetitive, two-pass en een zapping scenario.
Hoofdstuk 3 How to use log files from streaming media servers to determine learning processes Onderzoeksvraag: *Kunnen we log files van streaming media servers gebruiken om de leerprocessen van studenten vast te stellen en is er een link met het leerstijlmodel van Vermunt?*	Het leerproces van studenten kan gemonitord worden door het gebruik van log files. Echter, er is geen duidelijke link tussen de kijkscenario's van studenten en hun leerstijl.
Hoofdstuk 4 Using learning styles and viewing styles in streaming video Onderzoeksvraag: *Hangen kijkstijlen ook samen met persoonlijkheidskenmerken zoals gemanifesteerde leerstijlen en het kortetermijngeheugen? Kan het zich bewust zijn van het kijkgedrag bijdragen aan hogere leeruitkomsten?*	Het kijkgedrag van studenten bij streaming video is niet sterk gecorreleerd met het kortetermijngeheugen van studenten en hun leerstijl. Studenten zijn flexibel in het veranderen van hun kijkgedrag. Een instructie over het zich bewust zijn van het kijkgedrag verhoogt hun leeruitkomsten.
Hoofdstuk 5 Viewing video for learning Onderzoeksvraag: *Wat is het verschil in leereffecten (en retentieafname) tussen studenten met en zonder een instructie over het zich bewust zijn van alternatief kijkgedrag en wat is het effect van het niveau in voorkennis op leereffecten?*	Studenten met een strategisch of meervoudig kijkgedrag bereiken hogere leereffecten dan studenten met één soort kijkgedrag. Studenten met weinig voorkennis van de onderwerpen laten minder vooruitgang zien van hun metacognitieve vaardigheden dan studenten met enige voorkennis. Studenten ontwikkelden markeringstechnieken met de muis in de media speler op video's meer strategisch te bekijken.
Hoofdstuk 6 Discussion Uitkomsten, implicaties, reflectie en toekomstig onderzoek	

Belangrijkste uitkomsten van de experimenten

We onderzochten het kijkgedrag van studenten, terwijl zij aan het leren waren van instructievideo's. Het one-pass kijkgedrag, zoals het bekijken van de video's in één keer, werd verwacht. Ook verwachtten we het kijkgedrag waarbij een student de video terugspoelt, omdat hij een deel van de video niet begrijpt bij de eerste keer kijken.

Het two-pass kijkgedrag hadden we minder verwacht, omdat we de studenten hadden geïnstrueerd om de video terug te spoelen bij delen van de video die ze niet begrepen en niet te wachten tot het einde van de video. Eén van de studenten zei: "*Meestal spoel ik een deel van de film niet direct terug, omdat het regelmatig voorkomt dat een specifiek deel, dat ik opnieuw wil zien, later in de video wordt uitgelegd".*

Ook hadden we het zapping kijkgedrag niet verwacht. Dit bracht ons op het mogelijke verband tussen kijkgedrag en leerstijlen. Dit zappende kijkgedrag leek namelijk vergelijkbaar met het leergedrag van een student met de ongerichte leerstijl van Vermunt (1992). Deze mogelijke link tussen kijkgedrag en leerstijlen kon veelbelovend zijn, omdat we hiermee leermanagementsystemen meer gepersonaliseerd konden maken.

Er is een aantal mooie voorbeelden in de literatuur geweest van leermanagementsystemen met een dergelijke adaptieve component gebaseerd op leerstijlen. Eén van deze is *eTeacher*. Schiaffino, Garcia, & Amandi (2008) gebruikten een (software) agent gebaseerd op een Baysean netwerk en het leerstijlmodel van Felder & Silverman (1988). Bijvoorbeeld: als een student niet lineair is in zijn leerpatronen dan krijgt hij een samenvatting bij aanvang van de leertaak in plaats van aan het einde.
We zouden de informatie over een student in een dergelijk netwerk kunnen aanvullen, mochten we een link kunnen vinden tussen het kijkgedrag en leerstijlen.

We hebben geen duidelijke link gevonden tussen de meer pervasieve persoonlijkheidskenmerken, zoals het leerstijlmodel van Felder & Silverman (1988), het kortetermijngeheugen en het kijkgedrag van studenten. Echter, we vonden wel dat studenten flexibel waren in het veranderen van hun kijkgedrag zonder hun toetsscores te verlagen.
Ook bekeek meer dan de helft van de studenten video's strategisch.

Studenten met enige basiskennis over de onderwerpen die aan bod kwamen in de video's hadden het meeste voordeel van het gebruik van ander en nieuw kijkgedrag. Studenten met weinig voorkennis hadden het minste voordeel. Ook interessant was dat de leerwinst weer verdween na een aantal weken. Kennisverwerking lijkt slecht te gaan wanneer twee dingen tegelijk gedaan worden: leren van video én aanleren van nieuw kijkgedrag.

We hebben een onderscheid gemaakt tussen studenten met een smal kijkrepertoire (*one-trick* kijkers), studenten met een breed kijkrepertoire (*multi-trick* kijkers) en *strategische* kijkers. We vonden dat leereffecten van *one-trick* kijkers lager waren dan de leereffecten van *multi-trick* kijkers en *strategische* kijkers.

We concluderen dat interactieve video een modaliteit is die didactische meerwaarde kan hebben, in lijn met de conclusie van Hattie (2009). Aan sommige voorwaarden moet dan wel zijn voldaan: de technische en didactische kwaliteit van de video moet goed zijn, de integratie met een leertaak moet duidelijk zijn, studenten moeten zich bewust zijn van hun kijkgedrag en docenten moeten het kijkrepertoire van studenten pas verrijken wanneer studenten al enige basiskennis hebben.

Als aan deze voorwaarden is voldaan, zoals in onze onderzoeksopzet, kunnen leereffecten mogelijk met 20% verhoogd worden zoals in ons derde experiment.

Theoretische implicaties van de onderzoeksresultaten

De theoretische onderbouwing van het derde experiment is gebaseerd op eerder werk van Huai (2000), zij vond een correlatie tussen de leerstijl en het kortetermijngeheugen van een student. Zij signaleerde een parallel tussen de leerstijl van studenten en zijn of haar kortetermijngeheugen. Leerlingen met een zwakker kortetermijngeheugen en een holistische leerstijl moeten verloren elementen in het kortetermijngeheugen terugvinden door het actief werven en uitwerken van elementen uit het langetermijngeheugen. Leerlingen met deze holistische leerstijl bouwen aan een veel meer geïntegreerde kennisstructuur die zich terugbetaalt in termen van het flexibeler oplossen van problemen en een veel groter feitelijk repertoire op de lange termijn.
Wij konden deze link niet reproduceren. Huai gebruikte een andere test (Pask's Smugglers test) om de leerstijl te scoren op de dimensie serieel – globaal. Graf, Lin, & Kinshuk (2008) gebruikten de score van de dimensie *understanding* om de leerstijl te meten van een student toen ze de leerstijltest van Felder & Silverman (1988) gebruikten. Mogelijk was deze conclusie, die ook aan de basis lag van onze keuze voor de leerstijltest, niet correct.

Het vierde experiment (en ook het tweede deel van ons derde experiment) was gebaseerd op het werk van Cook (1991). Ze maakte studenten bewust van hun leerstijl door hen studietips te geven over hun leergedrag na drie weken onderwijs. Hun leergedrag was gebaseerd op de testscore van een leerstijltest die na drie weken werd afgenomen tijdens een cursus van tien weken. Ze vond in dit experiment significant hogere leereffecten bij het vergelijken van de resultaten voor studenten die wel bewust werden gemaakt van hun leerstijl met studenten die niet bewust werden gemaakt van hun leerstijl. We hebben geen studietips gebruikt op basis van de leerstijl van de student, maar suggesties op basis van hun eerdere kijkgedrag over mogelijk alternatief kijkgedrag. Onze resultaten zijn vergelijkbaar met de resultaten van Cook. We vonden ook hogere leereffecten, maar alleen voor studenten met voorkennis van de behandelde onderwerpen (fotografie in ons geval). Studenten met weinig voorkennis profiteerden het minst.

Een ander interessant feit betreft de onderzoeksopzet van Cook (1991). Studenten moesten een leerstijltest ondergaan na drie weken en niet aan het begin van de cursus. Op het moment van de leerstijltest hebben studenten al enige basiskennis van de onderwerpen en ze zijn dan beter in staat om studietips toe te passen dan zonder kennis van de onderwerpen. Interessante toevoeging zou zijn om het kennisniveau van de student te scoren bij het nemen van een leerstijltest, zodat we individuele studietips kunnen geven aan studenten. Normaal wordt dit niveau gemeten in een pre-post-test om leereffecten te berekenen aan het begin en aan het einde (maar niet ertussen).

Het ontwerpen van adaptieve leeromgevingen op basis van leerstijlen berust op het idee dat leerstijlen van studenten stabiel zijn in de tijd en tijdens leertaken. Het gebruik van leerstijlen is echter ook ter discussie gesteld: ze zijn een vereenvoudiging van de vele dimensies en kunnen nauwelijks de essentie van individuele leerkenmerken verklaren (Willingham, 2009).

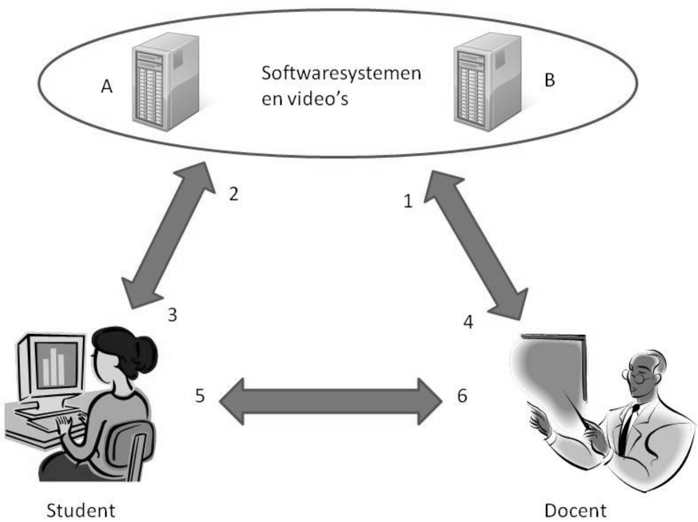
Sommige van onze studenten switchten hun kijkgedrag op basis van hun cognitieve behoefte en dit verlaagde hun testscore niet. Deze flexibiliteit van de student in het aanpassen van zijn of haar kijkgedrag is in lijn met de ontbrekende correlatie tussen pervasieve persoonlijkheidskenmerken en leerstijlen die we eerder in onze experimenten vonden.

Kozhevnikov (2007) onderzocht trends die naar voren zijn gekomen in literatuur over cognitieve stijlen om zo hogere cognitieve stijlen (metastijlen) te onderzoeken. Deze metastijlen gaan over de mate waarin individuen flexibiliteit vertonen in de keuze van stijlen en om deze ook zelf te kunnen monitoren. Het model dat we in hoofdstuk 5 geïntroduceerd hebben, die gebaseerd was op metacognitie, kan een beter begrip bieden van het kijk- en leergedrag van video. Het neemt in ogenschouw dat studenten moeten worden uitgedaagd om meer dan één soort kijk- en leergedrag in te zetten tijdens het leren van video.

Praktische implicaties van de onderzoeksresultaten

Het leerproces van een student kan als volgt worden gevisualiseerd (Figuur 1):

De docent ontwerpt en distribueert een leertaak met een instructie video (1). Een student opent deze leertaak met de instructie video (2) met een internet browser. De leertaak en video (3) worden ontsloten door middel van een leermanagementsysteem (A) en de streaming media server (B). Docenten kunnen ook instructies geven aan studenten (5) die gebaseerd zijn op informatie van de student (6). De servers geven de docenten informatie over het gebruik van de video en de leertaken (4).



Figuur 1
Het leerproces van een student

De praktische implicaties van de onderzoeksgebieden kunnen op vier verschillende gebieden worden geïmplementeerd:

1. *Docenten*
   We concludeerden dat studenten uitgedaagd moeten worden om meer dan één soort kijk- en leergedrag in te zetten tijdens het leren van video om zo hun metacognitieve vaardigheden te verbeteren. Ook leek het zo dat studenten, die weinig voorkennis hebben van het onderwerp, minder goed in staat zijn om hun metacognitieve vaardigheden te verbeteren, terwijl ze

leren van video. Hun kennisconstructie is slechter bij het doen van twee dingen tegelijk (multitasking): leren van video en het inzetten van nieuw kijkgedrag.
Leerkrachten moeten wel kijktips geven aan studenten, maar niet aan studenten zonder voorkennis. Dit kennisniveau kan onderzocht worden door middel van een pretest aan het begin of een tussentijdse toets tijdens een cursus. Zonder dit vooronderzoek moet studieadvies niet worden gegeven bij de aanvang van een cursus waar studenten meestal geen voorkennis hebben, maar pas na een paar lessen.

2. *Studenten*
   Studenten moeten bewust worden gemaakt van mogelijk alternatief kijkgedrag. Dit zou kunnen via docenten, zoals beschreven in de vorige paragraaf, maar ook door middel van een (online) instructievideo. Deze video kan gaan over kijkscenario's, zodat een student dit alternatief kijkgedrag kan leren. Ook moet een student in staat zijn om zijn eigen kijkgedrag te herkennen in een dergelijke instructievideo.

3. *Softwaresystemen (media spelers en streaming media servers)*
   Media spelers moeten ook de functionaliteit bieden voor studenten om hun eigen (meervoudige) markers te plaatsen op de voortgangsbalk (figuur 2). Op deze manier zullen ze niet beperkt zijn tot het gebruik van de muis als een marker, waarmee zij slechts één marker kunnen plaatsen.
   Alle links in de video, die tot nu toe besproken zijn, zijn interne links. Deze links verwijzen naar startpunten in de video zelf. Externe links naar andere video's kunnen worden ingebed in de video om de student te helpen met het leren van video (Zahn et al., 2004) Voortbouwend op hun ideeën, adviseren we om externe video's toegankelijk te maken via een lijst van deze externe links op de rechterkant van het scherm en de interne links aan de linkerzijde (figuur 3), of omgekeerd. Op deze manier zal de mogelijkheid voor studenten om de chronologische weergavemodus te verlaten beter worden ondersteund.

4. *Video*
   Tijdens het analyseren van de video-opnames van het leerproces van studenten, bleek dat sommige studenten - met een strategisch kijkgedrag - de muis gebruikten als een marker op de voortgangsbalk om hen te helpen herinneren aan de segmenten die opnieuw bekeken moesten worden. In het algemeen zouden media spelers meer mogelijkheden moeten bieden om deze studenten te helpen met hun zoektocht naar de inhoud die zij opnieuw willen weergeven. Een lijst van videosegmenten kan bijvoorbeeld aan het eind van de video worden gepresenteerd om hen een mogelijkheid te geven specifieke segmenten opnieuw te kijken. Dit zou gedaan kunnen worden door het koppelen van de startpunten van de segmenten van een video aan de voortgangsbalk (figuur 4). In deze figuur hebben we de videosegmenten van ons laatste experiment gebruikt. Bovendien zou een

dergelijke lijst kunnen worden gepresenteerd aan het begin van een video om een overzicht van de inhoud ervan te geven.
Niet iedereen in het onderwijs heeft een positieve houding ten aanzien van het gebruik van video. Soms wordt een video wel eens vergeleken met een boek, maar dan zonder structuur, zonder titelpagina, zonder naam van een auteur, zonder het aantal pagina's, zonder hoofdstukken en paragrafen, zonder een inhoudsopgave, zonder een index, enzovoort. Het gebruik van een dergelijke video (zonder titel, lengte, segmenten, et cetera) in het onderwijs vereist dat een student een video bekijkt zonder enig idee wat hij moet doen en hoe lang het zal duren. Dit is een voorbeeld van een video zonder integratie met een leertaak.
De kwaliteit van een video hoeft niet perfect te zijn, maar "goed genoeg". De video's die we in ons onderzoek gebruikten, werden als goed beoordeeld, zowel technisch als didactisch. Een student zei dat het niet nodig was om delen van de video opnieuw te bekijken, omdat de onderwerpen in de instructievideo goed werden uitgelegd. Slechte video's kunnen echter worden voorkomen door het gebruik van een aantal richtlijnen. Allereerst moet de video geïntegreerd worden met een leertaak. Verder moet het doel van de video uitgewerkt worden in de leertaak of de video zelf, samen met de optionele toetsen.
Wanneer video's didactisch niet goed genoeg zijn, moet een student de interactieve knoppen van een media speler vaker gebruiken. Het gebruik van de strategische ondersteuning (figuur 2,3 en 4) kan deze interactie verbeteren.

Figuur 2
Media speler met een functionaliteit voor studenten om hun eigen (meervoudige) markeringen op de progress bar te plaatsen

Figuur 3
Media speler met een functionaliteit voor interne en externe links

Figuur 4
Het segmenteren van video's voor eenvoudige navigatie voor studenten

Eén van de voordelen - na implementatie van onze praktische implicaties - is leeruitkomsten in de cursussen waar video wordt ingezet, mogelijk resulterend in minder onvoldoendes en meer geslaagden. Dit kan op zijn beurt leiden tot een stijging van de jaarlijkse budgetten in het hoger onderwijs en deze toename kan weer worden gebruikt voor een intensiever gebruik van video.
Een ander voordeel kan zijn dat de studenten - die zich bewust zijn van alternatief kijkgedrag - dit ook toepassen bij andere cursussen. In onze onderzoeksopzet hebben we dit gebruikt voor instructiekennis, maar we denken dat dit ook bij meer complexe onderwerpen kan helpen.
Tenslotte kan het zich bewust zijn van docenten van het leergedrag van studenten tijdens het kijken naar video's ook worden gebruikt in andere cursussen over instructiekennis.

De nadelen zijn van financiële aard en betreffen de kosten van het ontwikkelen en organiseren van deze cursussen voor studenten en docenten. Met de kosten van de ontwikkeling voor de nieuwe functionaliteiten van media spelers moet rekening worden gehouden en ook de met kosten van het implementeren van de richtlijnen voor video. Deze kosten zijn eenmalig en het zijn investeringen. Bovendien: de budgetten zullen jaarlijks toenemen, waardoor uiteindelijk de investeringen terugverdiend zullen worden.

De implementatie van bovenstaande praktische implicaties vergt een project dat gericht is op intensiever gebruik van video in het hoger onderwijs. Onze bevindingen, zoals cursussen voor docenten en studenten, aanvullingen voor media spelers en de integratie van video in de leertaken, zullen hierin aan bod moeten komen.

Reflectie op de onderzoeksopzet

Om leereffecten te meten is er een pretest en posttest ontworpen. Door het geringe aantal (twaalf) mogelijke vragen, kon een conventionele test niet worden gebruikt: beide tests konden dan slechts uit maximaal zes vragen bestaan. De invoering van een retentietest zou dit aantal verlagen tot vier.

Het *(absolute) leereffect* werd gedefinieerd als de posttest score minus de pretest score. We berekenden de voorkennis (pretest score) door de studenten te vragen, direct na de laatste multiple choice test, welke vragen ze konden beantwoorden zonder naar de bijbehorende instructievideo te kijken. Voor de posttest score, gebruikten we de gewone score van de multiple choice test.
Het beantwoorden van de vragen over hun pretest score werd goed gedaan door studenten. Men zou kunnen verwachten dat de studenten minder goed zijn in de reconstructie van hun voorkennis na de test, maar dit was niet het geval.

Sommige verschillen in leereffecten waren niet significant. Een mogelijke verklaring is dat de pre-, post- en retentietests onvoldoende test items hadden. Echter, het verhogen van het aantal test items zou ook het aantal informatie-elementen en ook de lengte van de video hebben verhoogd en daarmee mogelijk boven de richtlijnen van Verhagen (1992) en van ons zijn gekomen. Daarom hebben we de lengte van de video hetzelfde gehouden.

Toekomstig onderzoek

De instructievideo's die we gebruikten in onze experimenten waren op het kennisniveau van de taxonomie van Bloom (1956). Leren van video op dit niveau gaat meer over feitelijke informatie. We willen de experimenten herhalen waarbij de onderwerpen van de video's op één van de hogere niveaus van de taxonomie van Bloom (analyse, begrip, enzovoort) zijn.
Leren op hoger en dus meer complex niveau gaat over het verbinden van nieuwe kennis in de video met bestaande kennis. Dit zal mogelijk meer complexe leertaken vereisen die niet zo lineair zijn als degene die we gebruikten. We verwachten dat onze strategische functionaliteiten voor de media spelers nog nuttiger kunnen zijn bij deze complexe taken, bijvoorbeeld wanneer een student video's wil zien als onderdeel van een dergelijke leertaak.

We willen ook in de toekomst onderzoek doen naar het juiste moment voor het afnemen van een toets na een meer complexe taak of video. Tolboom (2012) vond dat onmiddellijke feedback bij procedurele kennis behulpzaam kan zijn voor studenten en dat vertraagde feedback nuttig kan zijn in geval van meer complexe (conceptuele) taken. De interactie van een student met een video - pauzeren enzovoort - kan worden gezien als een zelfgeïnduceerde vorm van feedback: een student begrijpt een deel van een video niet en bekijkt dit moeilijke deel van de video nog een keer.

Kennistoetsen moeten in het algemeen, na een meer complexe video- of leertaak, niet te vroeg worden gepland: een student heeft tijd nodig om de behandelde onderwerpen te begrijpen. Video's op een complexer niveau hebben waarschijnlijk een langere lengte dan de video's die we gebruikten in ons onderzoek, vanwege de meer complexe aard van de onderwerpen en ook vanwege een hoger aantal vragen en meer complexe vragen. Voor zeer complexe taken moet de uitgestelde feedback worden gegeven na de instructie, dus dit betekent ook het uitstellen van toetsen of andere taken, mogelijk tot een dag erna of zelfs meer dagen erna.

We willen ook andere toetsen overwegen - of andere organisatie van de toetsen - om leereffecten te meten, vooral wanneer de video's van een meer complexe aard zijn. Open vragen in plaats van multiple choice vragen kunnen gebruikt worden om steeds meer belangrijke leereffecten te testen, maar het automatische en directe nakijken zal dan niet mogelijk zijn, zoals wij deden in onze experimenten. Tenslotte kan het gebruik van concept maps verder worden onderzocht als een toetsinstrument.

Deze instructies over kijkgedrag aan studenten kunnen worden gedaan door de docenten, maar ook door coaches die gespecialiseerd zijn in metacognitie.

Docenten zijn tegenwoordig druk bezet tijdens de lessen in klassen met een groot aantal studenten. Met de inzet van deze coaches hebben docenten meer tijd voor hun eigen lessen en individuele uitleg, bovendien kunnen deze coaches dit efficiënter uitleggen.

De combinatie van al onze suggesties voor toekomstig onderzoek zou resulteren in het volgende onderzoeksvoorstel voor een promovendus.
Drie mogelijke onderzoeksvragen kunnen zijn:
-Wat is de invloed van het kijkrepertoire op leereffecten in een klaslokaal?
-Hoe kunnen tools voor strategisch kijken helpen om deze leereffecten te verbeteren?
-Wat is het optimale moment voor het bekijken van instructies en tests voor studenten in een klas?

De eerste stap in dit project betekent het inzetten van video's met een meer complex onderwerp dan eenvoudige instructievideo's. We adviseren het maken of kiezen van video's op de drie verschillende Bloom niveaus: kennis, analyse en begrip. Dit zou ons mogelijk in staat stellen het juiste moment van feedback en toetsmomenten aan studenten te onderzoeken, afhankelijk van het niveau van Bloom.
Bovendien zouden we de functionaliteiten ontwikkelen van de media spelers om het strategische kijken te ondersteunen.

De onderzoeksopzet zou een experiment zijn in een minder gecontroleerde omgeving, bij voorkeur in een klaslokaal. Twee klassen gaan een cursus volgen en één van hen zou complexe video als onderdeel van de cursus moeten hebben en de andere regulier lesmateriaal. Ook moeten de leerlingen een pre-, post- en retentietest maken om leerresultaten te meten, bij voorkeur geen multiple choice vragen, maar open vragen of concept maps. Tenslotte moeten de studenten in de videoklas na een aantal lessen een toets maken om hun kijkgedrag te meten en om hen bewust te maken van alternatief kijkgedrag. De afhankelijke variabele (DV) is het leereffect, de onafhankelijke variabele (IV) de pretest score. De timing van de feedback en de complexiteit van de onderwerpen kunnen de interventievariabelen zijn.

Alles overziend kunnen we zeggen dat het juiste gebruik van video in het hoger onderwijs zal leiden tot hogere leereffecten, betere video's en verbeterde media spelers. Studenten en docenten zullen zich meer bewust zijn van hun leer- en doceergedrag.

About the author

Jelle de Boer was born on February 3, 1960 in Hemrik, Friesland (The Netherlands). He obtained his high school education at 'Drachtster Lyceum' in Drachten (Atheneum-B). In 1978, he started his study Experimental Physics at the University of Groningen and completed this study in 1987. From 1983 till 1987 he was a student assistant at the University of Groningen.

From 1987 till 1998 he worked at the 'Saxion University of Applied Sciences' in Enschede as a teacher and developer in the area of mathematics, physics and programming. From 1995 till 1998 he worked as head of the Expertise Centre ICT and was member of the management team.

Since 1998, he is working at the ‘Hanze University of Applied Sciences’ in Groningen as a senior lecturer and developer in the area of web and mobile services. From 2003 till 2009 he was coordinator of an ICT infrastructure. He started his PhD in 2005 which was based on articles and was a speaker at several international conferences (EUNIS 2006, ELBA 2008, ELSIN 2010 and 2011, and SWAET 2012. His publications are about learning from video, learning styles and strategies, viewing behavior, and awareness.

Appendix 1: Knowledge test

The following 12 questions were used in the pre-, post-, and retention test:

Question 1 **10 points** Save

Wat wil de extensie .NEF zeggen?

- Dit is een extensie die Nikon gebruikt voor zijn eigen JPG bestanden
- Dit is een extensie die aangeeft dat het om een tijdelijk bestand gaat
- Dit is de extensie die Adobe Bridge nodig heeft om de foto te tonen
- Dit is de extensie die Nikon gebruikt voor de RAW bestanden

Question 2 **10 points** Save

Waar moet de Working Space op staan als je het RAW bestand in Photoshop opent?

- ColorMatch RGB
- sRGB
- Adobe RGB (1998)
- ProPhoto RGB

Question 3 **10 points** Save

Welke kleurdiepte kies je bij deze opname in Photoshop?

- 16-BITS
- 0,8-BITS
- 18-BITS
- 8-BITS

Question 4 **10 points** Save

Welke maat moet het te importeren bestand krijgen uit de fotocamera?

- de afmetingen van het stuk dat je eruit wilt overhouden na bijsnijden
- de gewenste maat van de foto in pixels
- de afmeting van de uiteindelijke foto die uit de printer komt
- de werkelijke maat van de foto (in dit geval 2000 * 3008 pixels)

Question 5 **10 points** Save

Bij een staande foto is :

- het formaat van de foto is portret
- de fotograaf staande tijdens het fotograferen van de opname
- het formaat van de foto is landschap
- het model op de foto staande

Question 6 **10 points** Save

Hoe kan ik de foto's op de Apple computer in de studio bekijken en bewaren
als ik de camera heb aangesloten met een USB kabel?

- Door Adobe Photoshop te starten
- Door de software van de Nikon camera te starten
- Door het programma Fotolader te starten
- Door alle foto's te selecteren en naar mijn Bureaublad te slepen

Question 7 **10 points** Save

Waarvoor wordt Adobe Bridge in de fotostudio gebruikt?

- Om de foto's te bewerken
- Om de foto's goed te kunnen beoordelen
- Om de Nikon RAW bestanden te kunnen bewerken
- Om de NEF bestanden om te kunnen zetten in RAW bestanden

Question 8 **10 points** Save

Wanneer is een studiofoto goed bruikbaar als je deze gaat beoordelen?

- Als de shaduwen nog voldoende doortekening hebben en de hoge lichten niet zijn uitgebeten
- Als het licht aan de juiste kant valt en er geen schaduwen meer optreden
- Als de kleuren goed doortekend zijn en de verzadiging van de lichte kleuren voldoende is
- Als de schaduwen geen doortekening meer hebben en de hoge lichten iets zijn uitgebeten

Question 9 **10 points** Save

Kun je in Photoshop ook foto's bewaren in .JPG?

- nee, dat kan alleen met Adobe Bridge
- ja, dit kan slechts in een stand voor de kwaliteit
- nee, dat kan alleen in bestandsformaten met een hoge kwaliteit
- ja, dit kan in meerderde kwaliteiten

Question 10 **10 points** Save

Het aantal pixels / inch moet zijn:

- 195
- 591
- 19
- 95

Question 11 **10 points** Save

Als je foto overbelicht zou zijn en uitgebeten is in de hoge lichten, wat moet je dan doen?

- Als de foto te licht is moet je dit aanpassen in het RAW venster van Photoshop
- Als de foto te licht is zal je het diafragma verder moeten knijpen, want de sluitertijd van de ca-mera staat vast in de studio
- Als de foto te licht is zal met een kortere sluitertijd moeten werken om de opname donkerder te kunnen maken
- Als de foto te licht is zal je 1 of meer studioflitsers uit moeten zetten

Question 12 **10 points** Save

Als je de kleurtemperatuur je niet zou bevallen tijdens het openen van een RAW bestand in Photoshop, wat kun je dan doen?

- ○ De resolutie met hele kleine stappen aanpassen tot je een neutraler resultaat krijgt
- ○ De waardes van de Tint met hele kleine stappen veranderen tot je een neutraler resultaat krijgt
- ○ De belichting met hele kleine stappen aanpassen tot je een pittiger resultaat krijgt
- ○ De waardes van de kleurtemperatuur met hele kleine stappen veranderen tot je een neutraler resultaat krijgt