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Using learning styles and viewing styles in streaming video

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A B S T R A C T

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 50 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.

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.

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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, Pedretti, Bencze, Vaillancourt, & Yoon, 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, and 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.

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 were 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 and Tolboom (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 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 1 shows a typical zapping scenario: short viewing times (*duration*) in each entry.

Table 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 and Tolboom (2008) defined four viewing scenarios: *one-pass, two-pass, repetitive* and *zapping scenarios*. Table 2 describes the viewing behavior of these four viewing scenarios.

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.

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 and 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 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 15–20 s 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, and 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 and 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

Table 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

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. 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, and 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, and 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, and 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 and 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, Rayner, & Armstrong, 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 and Tolboom (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 and 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, scores 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.

Table 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

5. Research setup

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

In this experiment, 50 undergraduate students in three groups at the Hanze University of Applied Sciences followed a nine week course about photography (Table 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.

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-min introduction lesson with five instructional videos and five multiple-choice tests on how to use photographic equipment (Table 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.

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, Schmand, de Sterke, & Lindeboom, 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 and 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 (Fig. 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 (van Gog, Kester, Nievelstein, Giesbers, & Paas, 2009). In this experiment however, the eye tracker was primarily used as part of the so-called retrospective think-aloud method (Guan, Lee, Cuddihy, & Ramey, 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.

Table 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

Fig. 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 pre-test of the first test design. In this first design there was only one video with all five segments and a length of 8:07 min with an assignment with 15 multiple-choice questions at the end. Students from this pre-test 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 pre-test. By adapting the instruction there was a correction for this phenomenon.

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 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 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

Table 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

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 6). The viewing behavior of the three viewing styles (linear, elaboration and maintenance rehearsal) is described in Table 2.

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 styles 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 styles lowers the test results, the total test score of the versatile students versus students was investigated with one preferred viewing styles. Switches viewing styles 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 7). Most students switched to an active style while viewing instructional video 3 and 5.

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 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 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

Table 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 and learning effects 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.

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. Schiaffino et al. (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 et al. (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.

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