MASTER THESIS

KEEP ONE'S ATTENTION ON RECORDED LECTURES

What effect do embedded questions in recorded lectures have on mind wandering and knowledge gain?

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Abstract

Lectures play an increasingly important role in education, for example in MOOCs and Flipped Classrooms. Recorded lectures are however not always as effective as possible, as mind wandering is a common problem for students. Research has shown that mind wandering can have detrimental effects on the learning process of emotional as well as factual nature. There are some initial indications that embedded questions could reduce the negative effects of mind wandering. Embedded questions could reduce mind wandering by keeping their attention to the literature. This can indirectly lead to knowledge gain, but embedded questions also directly improve knowledge gain through the testing effect. The goal of this study is to research *what the effect is of embedded questions in recorded lectures on mind wandering and knowledge gain.*

To do so, the current study is a mixed-methods design where quantitative data is supplemented by data from interviews. With a pre- and post-test experiment the effect of embedded questions on mind wandering and knowledge gain are researched. In the current research, no effect was found of embedded questions on either mind wandering or knowledge gain. Despite the existing consensus, there was also no negative relationship found between mind wandering and knowledge gain.

Inhoudsopgave

1 Introduction

Lectures are more important in education now than ever (Gorissen, Van Bruggen, & Jochems, 2012). Although they have played a vital role in the face-to-face classroom for years already, they are now also available as video-recorded lectures. These are not only used to support traditional classes but also as online video lectures which are fundamental elements of MOOCs (Massive Open Online Courses) and Flipped Classrooms (Chen & Wu, 2015). For Flipped Classrooms, the content of the recorded lectures is often used to generate prior knowledge for the in-class lessons (Herreid & Schiller, 2013). For the MOOCs, the recorded lectures regularly lead to some form of certification (Karsenti, 2013). To ensure that the students gain the knowledge intended, the recorded lectures should be as effective as possible (Schacter & Szpunar, 2015).

One well-known threat to the effectiveness and therefore to the knowledge gain of recorded lectures is the inability of students to keep their attention to the video (Gilboy, Heinerichs, & Pazzaglia, 2015). This inability of the learner to keep the focus on the important information is also called mind wandering (Corballis, 2012). Research has shown the detrimental effects of mind wandering on the knowledge gain of students. It leads to the fading of information without it having a lasting impact (Risko, Buchanan, Medimorec, & Kingstone, 2013). This is in line with research by Risko, Anderson, Sarwal, Engelhardt, and Kingstone (2012) who found that students who mind wandered more, performed worse on a retention test afterward. A follow-up study by Risko et al. (2013) found that students who were paying less attention to the lecture (e.g. answering emails whilst listening to the lecture) performed poorer on a subsequent test.

To make recorded lectures more effective, the students should, therefore, be helped to focus their attention on the relevant details of the video. A way to do so could be adding embedded questions. Research has already shown several benefits of embedded questions in video lectures, like a lower in-video dropout (Kovacs, 2016). There are some careful indications that embedded questions can also help with mind wandering (Schacter & Szpunar, 2015). If embedding questions would be solidly proven to also tackle mind wandering, it would be a clear and easy suggestion for practitioners to improve their own recorded lectures.

As shown, to get the best knowledge gain possible from a recorded lecture, students should be helped not to mind wander and to focus their attention. A promising way to do so is the addition of embedded questions. Therefore, the goal of this study is to research if embedded questions can help reduce mind wandering and enhance knowledge gain.

The current study is a mixed-methods design where the quantitative part is adapted from the unpublished study of Szöllősi and Meutstege (2019). They propose an experiment with a pre- and post-test where the effect of embedded questions in recorded lectures on mind wandering and knowledge gain is researched. This quantitative part will be supplemented with a qualitative part consisting of a questionnaire and interview.

To research whether embedded questions can help reduce mind wandering and enhance knowledge gain, a theoretical framework will be presented after this introduction. Here, relevant existing literature will be explored. After the theoretical framework, the method of the current study will be outlined, followed by a detailed description of the results. After the results section, the discussion and conclusion will follow where the new results will be compared to the existing literature and possible explanations will be presented. The last two sections will contain the references and appendices.

2 Theoretical framework

In this chapter, the existing theory relevant for this research will be reviewed. Initially, research about recorded lectures will be explored. The second paragraph will comprise of literature regarding attention which will be closely followed by a paragraph about mind wandering. The chapter will end with a paragraph about embedded questions and their yet researched effect on mind wandering.

2.1 Recorded lectures

Lectures have existed for a long time already and they are now also available as video lectures or recorded lectures (Chen & Wu, 2015). Video lectures have gotten increasingly important through their use in both MOOCs and Flipped Classrooms (Chen & Wu, 2015). Some experts have said that MOOCs will take higher education to a whole new level, but completion rates are rather low. Not even three per cent of the participants pass the exam at the end (Karsenti, 2013). As recorded lectures are a core feature of MOOCs, it is important to look at the quality of those to guarantee the best learning gain is ensured. Like with the MOOCs, the quality of the video lectures is also very important in the case of Flipped Classrooms. Students use the recorded lectures to prepare themselves for the work they will do in-class. Educators have already said, however, that it is hard to find videos of good quality (Herreid & Schiller, 2013). Recorded lectures can be enriched with audio and video instruction which is beneficial for the learning experience because people can learn more effectively when both words and pictures are used (Chen & Wu, 2015; Mayer, 2014). But just adding audio and a video does not guarantee sufficient advancement.

Video lessons offer students the autonomy to study at their speed and time. This has many advantages, but also offers challenges. Since the quality of lesson lies in the hands of the students, online video lessons heavily depend on self-regulated learning: *"a form of learning in which the learner is primarily responsible for initiating, managing and sustaining the learning process."* (Schacter & Szpunar, 2015, p. 61). According to Randall (2015), learners who are good at self-regulation should be able to keep their attention more on-task and should lose their attention less often. Since attention is crucial for effective learning (Risko et al., 2013), it is important to explore how attention works and how students could be helped to keep their attention to the learning task.

2.2 Attention

The contemporary world is more and more complex and distraction is everywhere, therefore students need to be able to steer their attention to effectively learn from current learning materials (Risko et al., 2013). During lectures, learners should keep their focus on the important information (D'Mello, 2016; Risko et al., 2013). The amount of research of attention has, however, not even been close to other fields related to learning like knowledge or actions. Since, as stated above, attention is required for learning, it can be said it is odd that this has not been researched more. What is known, however, is that just sustaining attention is not sufficient. The limited attentional resources must be effectively distributed by the learner to deal with the dynamic task loads and with the changing learning context. For learning to be effective, the learner has to be able to maintain and properly assign the limited attentional resources (D'Mello, 2016). Attention is needed for cognitive processes like for example the activation of prior knowledge. When attention is lacking, cognitive processes will be hindered (D'Mello, 2016).

D'Mello (2016) states there are four attentional states. A person can either be attentive or inattentive, which both can be overt or covert. Overt attention would be when a learner is focused on the learning material with both his eyes and his thoughts. When attention is covert, the learner would think about the learning content, but for an outsider, it looks like he is inattentive. This could, for example, be when the learner has his eyes closed for more concentration. When the learner is overtly inattentive, he is not thinking about the learning content and is off-task. Inattentiveness can, however, also be covert. In that last case, attention drifts away yet it may appear as if the learner is still focused on the task. Covert inattentiveness is also called *mind wandering* and research has shown that this can have very detrimental effects (Risko et al., 2012; Risko et al., 2013). For the best learning outcome of a student, a recorded lecture should adequately combat this covert inattentiveness, or, mind wandering.

2.3 Mind wandering

Learners failing to keep their attention to a task is common, especially during unexciting or redundant activities. Although the exact amount of mind wandering differs per person and context, a study by Killingsworth and Gilbert (2010) predicts that people mind wander

around 40% of the time. Everyone has experienced daydreaming about memories or upcoming plans while watching a video and then having to rewind a bit since there is no recollection of what has just been seen or heard (Smilek, Carriere, & Cheyne, 2010; Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011). Stawarczyk et al. (2011) also call this mind wandering *"stimulus-independent and task-unrelated thoughts"* (p. 370), or SITUTs. Mind wandering can even occur when the learner is trying hard to keep their attention to the task (D'Mello, 2016).

There is less consensus on the causes of mind wandering. Smallwood (2013) names different hypotheses, namely the executive failure hypothesis, meta-awareness hypothesis, the decoupling hypothesis, and the current concerns hypothesis. The idea that mind wandering can be caused when control over attention is lost and the learner, therefore, becomes more vulnerable to distraction is called the executive failure hypothesis. The meta-awareness hypothesis suggests that learners are able to recognize when they are mind wandering due to dynamic mental self-monitoring. The decoupling hypothesis suggests that internal and external processes are separated from each other. Therefore, mind wandering (internal) competes autonomously with task performance (external) for attention. The last hypothesis, current concerns (Klinger, Gregoire, & Barta, 1973, in Smallwood, 2013), focuses on the main concern of the mind in combination with the available stimuli and how they influence the thoughts of the learner. This hypothesis suggests that things like yearnings, aspirations and goals which go beyond the perceptual moment can cause mind wandering. The learners' thoughts will focus on the most prominent event, which means that if there are not enough stimuli from the lesson, the focus of the learner will shift towards self-generated thought. In other words, the learner will mind wander. A fascinating movie or interesting social interaction, following the current concerns hypothesis, might be stimulating enough for the learner to keep his/her focus (Smallwood, 2013). This means that learners will mind wander when 1) the task is not stimulating enough, and/or 2) they have more prominent off-task stimulation. Since it is outside the scope of the research to study all hypotheses, the current study will focus on the current concerns' hypothesis, which is more relevant now than ever. In the news, there is talk about adults experiencing a lot of stress.

For example, research by a Dutch newspaper Metro[1] showed that 75% of the youngsters in the Netherlands experience stress because of reasons like 'insecurity', 'pressure on work/internship', or 'too many choices at a too young age'. Another article by a Dutch newspaper, de Volkskrant[2], stated that the mental pressure is becoming dangerous and harmful for the health of youngsters. Part of this research will, therefore, explore the current concerns hypothesis.

By enlarge, research shows a negative relationship between mind wandering and learning processes. Although there is some debate about which one is the cause and which the effect, research has shown that people are generally less happy when mind wandering than when they are not (Killingsworth & Gilbert, 2010). Not only does mind wandering have a negative effect of an emotional nature, mind wandering causes negative effects of a factual nature as well. For example, research by Randall, Oswald, and Beier (2014) showed that there is an unfailing negative relationship between mind wandering and on task performance. Not only are there initial findings for mind wandering to be related to unhappiness, but there are more negative sides to mind wandering. For tasks that require nonstop attention, mind wandering can have detrimental effects and cause mistakes (Smilek et al., 2010). Since mind wandering involves an attentional shift from the external environment to internal thoughts, the learner is no longer attending the important learning content. That in turn occasionally leads to the absence of important knowledge for the learner and result in mistakes (Bixler & D'Mello, 2015; D'Mello, 2016). Research by Risko et al. (2012) showed that learners who mind wandered more often, remembered less about the lecture. When a learner starts to mind wander, it can cause the just learned information to fade. The learning then will not have any long-term effect (Risko et al., 2013).

Bixler and D'Mello (2015) state that the strategies to combat mind wandering can be divided into two categories. The first category is *proactive*, which refers to strategies preventing the mind wandering from happening (e.g. mindfulness training). The second category is *reactive*, which refers to strategies that address the mind wandering while it is

[1] https://www.metronieuws.nl/nieuws/dossier/2017/06/longread-waarom-we-ziek-worden-van-drukte Retrieved on 20/08/2019.

[2] https://www.volkskrant.nl/nieuws-achtergrond/mentale-druk-op-jongeren-neemt-gevaarlijke-vormen-aan~bd73895c/ Retrieved on 20/08/2019

happening. This can be done by tailoring the environment so that mind wandering becomes less likely to happen. D'Mello (2016) states that there are some common goals that the approaches to reduce mind wandering share: *"(a) capturing attention, (b) giving the learner an opportunity to reflect on the content/activity, and (c) providing an opportunity to correct any comprehension deficits due to mind wandering"* (p. 652). Embedded activities who have these goals can combat (the effects of) mind wandering (D'Mello, 2016; Szpunar, Khan, & Schacter, 2013). Capturing the attention of the learner would show in learners with embedded questions mind wandering less than learners without embedded questions. The opportunity to reflect for the learner would show in learners who would go back in the video to search for the answer of the embedded question. The opportunity to correct comprehension deficits would show in a higher learning outcome for participants with the embedded questions as opposed to the learners without embedded questions.

2.4 Embedded questions

Theory shows that embedded questions make the learners retrieve information from memory. This can cause the 'testing effect': long-term memorisation of the learned material. Empirical research has proven that the testing effect can improve retention of the material more than additional study. For the testing effect to take place, feedback or perfect performance is not necessary (Roediger III & Karpicke, 2006). So far, instructions often consist of a teacher giving answers or explanations to learners and hence fail to make use of this testing effect. Video lectures can, therefore, improve the learning of the students by adding probes or embedded questions to make them think about the answers/explanations themselves (Williams, 2013). There are also some positive effects found of embedded questions on mind wandering, but experiments so far have mostly been a first step (Schacter & Szpunar, 2015; Szpunar et al., 2013). Szpunar et al. (2013) did two experiments to research the effect of embedded questions on mind wandering and knowledge gain. In the first experiment (n = 32), they had a condition where participants received embedded questions after each segment and another condition where students only received a test after watching all four segments. To measure mind wandering, the research used seven-point rating scales. In the second experiment (n = 48), Szpunar et al. (2013) replicated their first experiment with a few changes. The first was the way they measured mind wandering, which was now through thought-probes: a researcher sat next to the participant and asked

them at random moments whether or not the participant had been mind wandering. The participant then had to write either yes or no on a piece of paper. A second difference was that they added another condition who could restudy the learning content to make sure the learning and attentive benefit came from the embedded questions and not just the re-exposure to the study materials. The study showed that embedded questions in a video lecture can directly lead to less mind wandering which in turn resulted in better learning. It was also shown that the learners that had embedded questions learned more than the students who did not have embedded questions and even learned more than learners who had the chance to restudy the material. Not only did they conclude that embedded questions can reduce test anxiety, but also that the questions improve learning by helping the learners to combat mind wandering and keep their attention to the video lecture. Since the research of Szpunar et al. (2013) is only, as they say themselves, an initial step, the effect of embedded questions on mind wandering should be explored further, which is the goal of this research.

2.5 Research questions

After exploring the presented theory, some questions are still unanswered. The main aim of this research is to fill in the gaps in existing theory. The main research question is: *What is the effect of embedded questions in recorded lectures on mind wandering and knowledge gain?*

To answer this research question, the following sub-questions are asked:

1. **What is mind wandering like in a real-life situation?**
   Since this research is the first to study mind wandering in a realistic environment, there are no real expectations.
2. **What is the effect of embedded questions in recorded lectures on mind wandering?**
   Although findings so far have been mostly initial, it is expected based on the study of Szpunar et al. (2013) that embedded questions will reduce mind wandering.
3. **What is the effect of embedded questions in recorded lectures on knowledge gain?**
   Research has shown that embedded questions can elicit the testing effect and can thus improve retention (Roediger III & Karpicke, 2006). It is therefore expected that embedded questions will lead to higher knowledge gain.

4. **What is the relationship between mind wandering and knowledge gain?**

   By enlarge, research shows a negative relationship between mind wandering and learning processes (Bixler & D'Mello, 2015; D'Mello, 2016; Randall et al., 2014; Risko et al., 2012; Risko et al., 2013; Smilek et al., 2010). It is therefore expected that a relationship will be found between mind wandering and knowledge gain and that this will be a negative one.

3 Method

3.1 Research design

The research will be a mixture of both quantitative and qualitative. For the quantitative part, an experiment with an instructional video will be done. The instructional video will be segmented. The experimental group will receive embedded questions in between the segments and the control group will watch the segmented video without the embedded questions. All participants will receive probes during the video which ask them whether or not they are mind wandering. Before the video, all participants will fill in a questionnaire about mind wandering and after finishing the video, both groups will receive a retention test to study the learning outcomes. For the qualitative part, the students will participate in structured interviews about their mind wandering and how they experienced the video with/without embedded questions. The interviews will be structured since that will help with the comparison between participants (Colton & Covert, 2007).

3.2 Respondents

Both mind wandering and therefore the knowledge gain differs when a video is easy or hard to grasp for the respondent (Smallwood & Schooler, 2006). It is therefore important to match the prior knowledge and learning capability of the participants to the level of content of the video lecture. To ensure that the participants are all more or less equal in this regard, a hard requirement for the level of schooling the participant has had is set. All participants need to have finished at least secondary vocational education. Since the video lesson consists of a lesson 'Introduction in Law', it was a prerequisite that the participant had not studied law.

All participation with this experiment will be voluntarily, which means that this sample will not be random. Assignment of the participants to the experimental or control condition, however, will be random as that is the optimal method (Gersten et al., 2005). This means that all participants have an equal chance to be in either the control or the experimental group. As the goal of this research is to measure group difference (between the control and experimental group), 30 participants per group is deemed sufficient (VanVoorhis & Morgan, 2007). This means that at least 60 participants were needed in total. All participants had to give informed consent before participating.

In total there were 61 participants. Three participants had to be excluded from the initial dataset because of problems with the pre- and post-test. Therefore, a dataset of 58 participants was used for calculations, of which 60,3% were female, 37,9% were male and the last 1,7% would not tell. The mean age was 24,60. In terms of prior schooling, 32,8% had been to university level schooling, 36,2% had been to a university of applied sciences, 22,4% had finished vocational education while 6,9% had finished high school and 1,7% something different. When asked what direction their school was, 22,4% answered healthcare, 20,7% technical, 15,5% education, 10,3% business, 6,9 economy, 6,9% had a service orientation and 17,2% something else.

3.3 Procedure

The procedure started with potential participants receiving the question of whether or not they wanted to participate via mostly social media (Facebook, Whatsapp, etc.). It was made clear that to participate, the person should have at least finished vocational education and not have studied law.

To ensure a natural environment, participants were asked to sit at a place where they could see themselves studying normally. This could be a desk in a study room or a kitchen table at home. The participants were asked to sit down behind a computer and go to the starting page. A list with supplies was shown which stated that the participant should get the following things: computer or laptop, pen, and the form for the measuring of mind wandering (see Appendix A: Form reporting mind wandering). Then, the participant had to watch an introduction video where the entire procedure was explained. Important parts here were how to navigate through the website and the explanation of how to report mind wandering. Also, a definition of mind wandering was given, which is the following:

> *"Having thoughts that have nothing to do with the task you have to carry out. This includes thoughts like: "What shall I eat tonight?", "I am really busy", but also: "What is this assignment boring".*[3]

[3] Translated from Dutch

Then, the participant had to press a button and they would receive a randomized login number between 1 and 10000. This was done to ensure anonymity and to make it unlikely that people would use the same login name/number. The page ended with a link to the research environment in Graasp, which had a 50/50 chance to go to either the experimental or the control environment to guarantee that every participant had an equal chance to get either condition.

In the research environment, the participant had to log in with the just mentioned randomly generated number. On the first page, they had to sign an informed consent form. On the next page, the participant filled in the questionnaire about mind wandering, directly followed by the pre-test. After finishing that test, the learner watched the segmented video. Each segment was on a different page and had to be started manually by the participant. If the participant was part of the experimental group, he/she also had to answer embedded questions in between the segments. After finishing the video, the participant had to fill in the post-test. When the participant was done with this second test, there was a last page with debriefing stating which condition the participant had been part of. The environment ended with several questions regarding whether the participant would participate in the interview and whether or not they were interested in the results of the research, points for the UTwente, and/or VVV-coupons. In total, took every participant about 45 minutes.

If the participant had expressed interest in participating in the interview, the researcher would contact them and schedule a meeting. The interviews took about 10 minutes per interview.

3.4 Instrumentation

In this chapter, the instruments which were used in the research are described. All of the research took place in Graasp. Two different environments were created: one for the control group and another for the experimental groups with the only difference being that the experimental group had embedded questions added after each segment. Graasp was used for this research because of the ease of use and many options it offers.

For the video, a recording of a lesson from the University of Delft was used. The lesson is Introduction in Law. This video was chosen because it is a good representation of what a recorded lecture looks like (a combination of lecturer and PowerPoint slides). Also, since it is introductory, no specific prior knowledge was needed.

3.4.1 Instrumentation for embedded questions

The difference between the control and experimental group is that the latter received embedded questions in between the video segments. Each embedded question was shown directly underneath the video in the format of another video. See Appendix B: Impression embedded questions to see what this looked like on the webpage. This was done so the participant was not able to immediately see the question, but only when watching the embedded question video after finishing the video lecture segment.

Each embedded question was about the content of the segment shown before the question so that it could elicit the before mentioned testing effect. Thus, the question was about already viewed material. As stated before, feedback is not necessary for the testing effect to take place (Roediger III & Karpicke, 2006). To make sure the experimental group did not get any extra information except for the questions themselves, no feedback was added.

Examples of used embedded questions are: “What is jurisprudence?” and “Which jurisdictions are part of public law? And what do these entail?”. For all embedded questions, please see Appendix C: All embedded questions.

3.4.2 Instrumentation for measuring of mind wandering

To measure mind wandering as objectively as possible, the use of physiological measures was considered. Eye-tracking has been used for measuring mind wandering. Most of those researches have however studied eye movements while the participant was reading a text, and not watching a video (Bixler & D’Mello, 2015; Franklin, Broadway, Mrazek, Smallwood, & Schooler, 2013). The eye movements have proven to be a lot more complex when the participant is watching a video (Mills, Bixler, Wang, & D'Mello, 2016). Research by Mills et al. (2016) has shown that eye-tracking might potentially be good for studying mind wandering when watching videos as well. At this moment, however, the relationship between eye movements and mind wandering while watching a video is not sound enough yet to rely on for accurate measurement of mind wandering. More research in this field is necessary because of issues like generalisability of existing models and the accuracy of mind wandering detection (Bixler & D’Mello, 2014; Mills et al., 2016).

3.4.2.1 Probe-caught method

Since like explained eye-tracking is no option, other instruments will be used in this research. According to Smallwood and Schooler (2006), experience sampling (or thought sampling) is the most commonly used method to measure mind wandering. Killingsworth and Gilbert (2010) argue that experience sampling is the most reliable method to investigate real-life sentiments. They explain experience sampling as reporting the current thoughts, feelings, and actions of the participant while they engage in an activity. In this research, experience sampling will be used to measure the inner experience of the participant during the experiment (Smallwood & Schooler, 2006). Probe-caught measures, which are a type of experience sampling, will be used. The participants will receive several probes during their viewing of the recorded lecture. Risko et al. (2012) showed that some well-placed probes can reveal interesting attention patterns in connection to mind wandering while disturbing the primal task only minimally. Regarding the probes, an adaptation of the method of Zhao, Lofi, and Hauff (2017) will be used. Like in their research, an auditory signal will be used as a probe. This auditory signal is a certain 'beep' that the participants will be familiarized with upfront. During every minute of the video (0:00-1:00, 1:00-2:00 etc.), there is one probe. The specific moment within that time frame will be randomized so that the participants will not be disturbed completely systematically, which is perceived as less interrupting (Bixler & D'Mello, 2014). However, after randomizing the moment of the probes, they were sometimes delayed or forwarded if that would disturb the viewing of the video less. For the full procedure of the placement of the probes in the video, please refer to Appendix D: Probe-placement procedure.

To report the mind wandering, the participant has printed out a form which showed a table to fill in for every segment, like Figure 1. For the full form, see Appendix A: Form reporting mind wandering.

Segment 1

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Figure 1. Example of where to report mind wandering for Segment 1. Translated from Dutch.

The participant was instructed up front, during the earlier mentioned introduction video, that if he/she had been mind wandering between the former and the current bell, he/she had to write an X under “Yes”. If the participant had NOT been mind wandering, he/she has to put a dash under “No”. The probing process is illustrated in Figure 2.

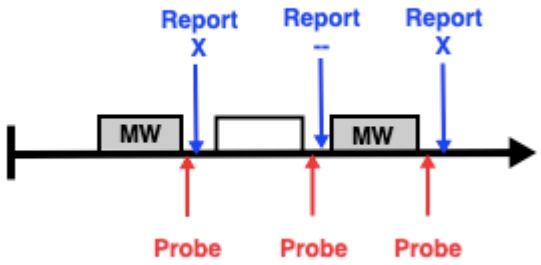

Figure 2. An example of mind-wandering reports. Adapted from Zhao, Lofi, and Hauff (2017).

In the image it is shown that after a probe (auditory signal), the participant has to think: “did I mind wander?” and report with either an X or a –, depending on the answer to the question. The participant was asked to use the paper for reporting mind wandering during the video because that should 1) be less distracting than having to scroll down during the video to use the online tool and 2) would be more naturally close to for example note-taking. After the participant has watched a whole segment, there was a tool in the environment where the participant had to copy the data from the on-paper mind wandering report. This tool can be seen in Figure 3.

Figure 3. Did you mind wander? Tool for reporting mind wandering in Graasp.

The participants had to fill in ‘yes’ or ‘no’ for every probe in the video lecture.

3.4.2.2 Usage logs

To measure video engagement, a data log was constructed for each video segment. In the columns, the measured variables were shown and in the rows the participants. The following variables were displayed in columns from left to right:

1. **Participant number.** Every participant was referred to with the randomized login number mentioned in paragraph 3.3 Procedure. These numbers were between 1 and 10000.
2. **Condition (coded).** Here the condition will be coded with either 0 for the control condition or 1 for the experimental condition.
3. **Playtime.** This is the total amount of time spent on the video. Plays, replays and pauses are all included.
4. **Unique playtime.** Here an estimation of how much of the video has been reviewed is shown in percentages. This is done through measuring whether every separate second has been set in "play-mode".
5. **Replay time.** In this column, it is shown in percentages how much of the video a participant has played again after seeing the full video. Like the unique play rate, this is measured by checking whether a second of a video has been set in "play-mode", but this time after the entire video was already finished.

3.4.2.3 Questionnaire and structured interview

Both the questionnaire and the structured interview were used to get insight into the person's experience with mind wandering. The questionnaire will give more insight into the opinion of the participant, as a questionnaire can measure beliefs and attitudes (Colton & Covert, 2007). This can help explain possible relationships. The items were structured to a few possible answers with a Likert scale, which makes categorization and with that comparison of the answers easier (Colton & Covert, 2007). The structured interview is used to dig deeper into issues that the questionnaire might not uncover (McKenney & Reeves, 2012). The interviews were recorded so that the researcher can first focus on the interview and later code the answers of the participants. The questionnaire consisted of three types of questions. The first type asks about effects directly after the video, like "After watching a video lesson, I soon forget the content". The second type of questions are about video lessons themselves. For example: "A video lesson is a good way to gain knowledge for me."

The third and last type consisted of questions about the feelings/thoughts of the participants during the video, such as “While watching a video lesson, I Mind wander when I am stressed”. For the full questionnaire, please see Appendix E: Questionnaire.

For the interview, there were several topics the questions focused on. The interviews started with questions about the experiment itself, like “What did you think of your concentration during the video?”. Other questions were about causes of mind wandering (“When do you mind wander?”), how they combat mind wandering, or what feelings of the participant towards mind wandering are (“If you mind wander, what does that to you?”). For the full interview please see Appendix F: Interview. All interviews were recorded.

3.4.3 Instrumentation to measure knowledge gain

To measure knowledge gain, a pre- and post-test are constructed. The tests were based on the contents of the recorded lecture used for the experiment. Both tests are mostly based on the same topics. Questions are for example “What is meant by the legalistic approach of law? (3 points)” or “Only building plans for dormers with a width of four meters get a permit of the councillor of spatial planning. Is this allowed? Why yes/no? (3 points)”. For the full pre- and post-test, see Appendix G: Pre-test and Appendix H: Post-test. Two questions are repeated and other questions are slightly different. In the pre-test, one question was left out since it required really specific knowledge from the video lectures so it would have been unfair to expect of the participants to know that upfront. This resulted in the pre-test having 10 questions while the post-test consisted of 11 questions.

The tests were analysed with the taxonomy of bloom (Krathwohl, 2002), to make sure not all questions required the same type of cognitive process. Of the total of 11 (post-test) questions, six were ‘Remember’ questions, 2 were ‘Understand’ questions, 2 were ‘Apply’ questions and 1 was an ‘Evaluate’ question. Most questions are thus from the lower parts of the taxonomy. This is deemed appropriate since there is enough variation and the test is about a video of an introductory level.

3.5 Data analysis

In this paragraph, the analysis of the data is described. The paragraph starts with the quantitative data divided based on the variables, starting with the independent variable

(condition), followed a presentation of the dependent variables (mind wandering, video engagement and knowledge gain). The data analysis ends with the qualitative data, where will be explained how the interviews will be analysed.

3.5.1 Condition

Since the effect of embedded questions cannot be measured directly, it is done indirectly through an experiment with a control group. They both follow the same procedure, with the only difference being the experimental group receiving embedded questions while the control group does not. It was shown by the data that all participants from the experimental group did see the embedded questions. Any differences between the groups are therefore from the embedded questions.

A check on the randomization of participants showed an equal distribution of gender over conditions. However, age was not equally distributed. A one-way ANOVA showed that age was significantly different over conditions F (1, 56) = 4.60, p = .036. Analyses with ANOVAs have been done with and without age as a covariate, but differences in the outcomes were small. It is therefore furtherly ignored.

3.5.2 Mind wandering

Like mentioned earlier, for measuring mind wandering the probe-caught method was used. As stated in 3.4.2.1 Probe-caught method, it gives yes/no data per participant for each probe. These are converted to a dichotomous variable were 0 means ‘yes’ and 1 means ‘no’. However, some participants did not fill in the same of yes/no’s as there were probes in a segment. For example, for segment 2 a participant might have reported 5 yes/no’s. However, in segment 2 there were only 4 probes, which means there is one report too many. In this case, it was assumed that the participant reported also for the moment between the last probe and the end of the video. The last report was thus deleted from the data set.

There were, however, also participants who reported too few yes/no’s. For example, for segment 1 a participant might have filled in two 1’s and two 0’s. This means that the participant has reported a total of 4 times for segment one, while in segment 1 there was a total of 5 probes. The mean of the reports in that segment was calculated, in this case, 0.5. This mean was then used for calculations instead of the missing value.

For each participant, a total was calculated per segment (a total of 5). This total is converted to a percentage since the number of probes differed per segment. Therefore, these percentages are used in repeated-measures ANOVA to see if there is a trend (difference over time) in mind wandering. Also, a total of all mind wandering per participant is calculated. Due to non-normal distribution, non-parametric Mann-Whitney tests were used to test whether the mind wandering of the participants differed significantly between the control and experimental group. For the analysis of the difference in the total of mind wandering in the mean totals of all mind wandering between conditions, multiple (stepwise) regression is used.

To analyse what mind wandering looks like in a natural situation, the probe-caught measures will be used to see what the mean amount of mind wandering is. The data from the questionnaire will be used to get a general idea of what people's perception is of how video lectures influence their attention and knowledge gain. First, it is important to know whether or not the questionnaire data is reliable. For reliability testing, question 1, 4, 6 and 7 were reversed. The questionnaire proved to have good reliability of Cronbach's $\alpha = .88$. With the data, a principal axis factor analysis with oblique rotation will be performed to see which factors can be extracted from the questionnaire and how much of the variance they explain. The newly constructed factors will then be used in a multiple linear regression analysis to test whether or not they are related to mind wandering data from the experiment.

3.5.3 Video engagement

To analyse the effect of embedded questions on video engagement, the playtime, replay time and unique playtime will be compared between the control and experimental group. This data comes from the earlier mentioned video engagement tool in Graasp. These will be compared through multiple (stepwise) regressions. In case of replay time, it is important to also look at frequencies (how many participants used replay and how many didn't). This will be done through a Mann-Whitney test.

3.5.4 Knowledge gain

To measure the knowledge gain, the pre- and post-test (see Appendix G: Pre-test and Appendix H: Post-test) will be compared. Before the analysis, the data had to be prepared.

First, a total of points for both pre- and post-test were calculated per participant. Secondly, these totals of points were converted into percentages since the total amount of points to get per test were different. As a last step of preparation, the *knowledge gain* was calculated by subtracting the percentage of the pre-test from the percentage of the post-test. The pre-test consisted of 10 items, however one was excluded in reliability tests due to it having zero variance. The remaining 9 items had a Cronbach's alpha of .72. The post-test had a Cronbach's alpha of .76. This means that both the pre- and post-test had acceptable reliability. Half of the items were scored by another research to measure reliability. Cohen's Kappa showed for the pre-test .747 and for the post-test .589, which is acceptable inter-rater reliability and means that the scoring of the tests has been reliable. A check on the randomization of participants showed an equal distribution of pre-test score over conditions.

SPSS will be used to compare the mean knowledge gained of the control and the experimental group with a repeated-measures ANOVA. When the results from the experimental and control group are compared, conclusions can be made whether the student who watched the video with embedded questions gained knowledge more, less or equal to the student who watched the video without the embedded questions. It will also be

3.5.5 Relation mind wandering and knowledge gain

To see whether mind wandering could influence knowledge gain, a linear regression will be done. For mind wandering, the sum of mind wandering per segment (so the total of mind wandering in the entire video) will be used. For knowledge gain, the earlier mentioned constructed variable will be used.

3.5.6 Interview data

The recordings of the interviews were transcribed for better analysis. These transcriptions then were studied to see whether there were any similarities and/or differences between the statements of the interviewees. Since the interviews were semi-structured, the answers to the questions could be compared directly. However, the transcriptions were also coded and sorted to see if there were any relevant statements which were maybe not directly answers to interview questions.

The data from the interviews will be used mostly to analyse what mind wandering is like in a realistic environment and what the effect is of the embedded questions on mind wandering.

4 Results

In this chapter, the results of the analyses are shown. First, the quantitative data will be presented starting with data regarding mind wandering which will be followed by the data concerning knowledge gain. The second part of this chapter consists of the qualitative data from the questionnaires and interviews.

4.1 Mind wandering

In this paragraph, the results concerning mind wandering are shown. See Table 1 for an overview of the amount of mind wandering/attentiveness in percentage of the control and experimental group for each segment and in total. A higher number means less mind wandering.

Table 1. Mean of Control and Experimental Group of Mind Wandering per Segment and Total in Percentages.

		N	Mean	*SD*
MW seg. 1	Control	28	58.09	25.76
	Experimental	28	60.18	26.89
MW seg. 2	Control	30	63.61	25.66
	Experimental	28	60.71	23.00
MW seg. 3	Control	30	59.77	27.99
	Experimental	28	59.64	24.26
MW seg. 4	Control	30	46.67	30.32
	Experimental	28	54.46	30.47
MW seg. 5	Control	30	50.75	27.39
	Experimental	28	46.90	30.54
Total	Control	27	57.00	20.61
	Experimental	28	56.38	21.02

The difference in mind wandering between the control and experimental group was analysed per segment. To measure whether there is a difference in mind wandering between the control and experimental group in the first segment, a Mann-Whitney test was conducted. The test showed that the amount of mind wandering did not differ significantly between the experimental (N = 28, M = 29.04) and the control (N =28, M = 27.96) group, U = 407.00, z = .251, p = .802.

To see whether there is a difference in the means of mind wandering between the control and experimental group in the second segment, a Mann-Whitney test was conducted. The amount of mind wandering did not differ significantly between the control (N = 30, M = 30.50) and the experimental (N = 28, M = 28.43) group, U = 390.00, z = -.487, p = .627.

Another Mann-Whitney test was conducted to analyse whether there is a difference in mind wandering between the control and experimental group in the third segment. The test showed that the amount of mind wandering did not differ significantly between the control (N = 30, M = 30.15) and the experimental (N = 24, M = 28.80) group, U = 400.50, z = -.312, p = .755.

To examine the difference in the fourth segment between the mind wandering of the control and experimental group, again a Mann-Whitney test was done. It showed that the amount of mind wandering did not differ significantly between the control (N = 30, M = 27.70) and the experimental (N = 28, M = 31.43) group, U = 474.00, z = .855, p = .392.

Again, a Mann-Whitney test was conducted, this time to analyse whether there is a difference in mind wandering between the control and experimental group in the fifth segment. The test showed that the amount of mind wandering did not differ significantly between the control (N = 29, M = 29.95) and the experimental (N = 28, M = 28.02) group, U = 378.50, z = -.444, p = .657.

A multiple regression (stepwise) analysis was performed to see whether condition, age or the pre-test score could predict mind wandering. Based on the results of the study (N = 55), the condition is not significantly related to the mind wandering of the participants, r = -.017, p = .451. Age is also not significantly related to mind wandering, r = .140, p = .154, as well as pre-test score, r = .004, p = .488.

To measure whether the amount of mind wandering differs significantly between the segments, a repeated-measures ANOVA was done. Age was used as a covariate. Mauchly's test indicated that the assumption of sphericity has not been violated, X^2 (9) = 5.106, p = .825. The results show that the amount of mind wandering did differ significantly between

the segments, F (1, 52) = 2.45, p = .047. This means that over time, participants started to mind wander more.

4.2 Video engagement

In this chapter, the video engagement of the control and experimental group will be compared to analyze whether there are differences or not. For an overview of the video engagement, please see Table 2. The data of the playtime, unique playtime and replay time of all participants are used for this analysis. For definitions of these variables, please see paragraph 3.4.2.2 Usage logs).

Table 2. Video Engagement. A higher number means a higher (re)view time.

		N	Mean	*SD*
Playtime	Control	30	295.73	56.01
	Experimental	28	317.33	43.73
Unique Playtime	Control	30	287.83	53.65
	Experimental	28	301.61	17.80
Replay Time	Control	30	1.80	7.11
	Experimental	28	8.40	23.33

A multiple regression (stepwise) analysis was performed to see whether condition, age, the pre-test score, or mind wandering could predict the playtime. Based on the results of the study (N = 55), condition is not significantly related to playtime, r = .219, p = .054. The trend shows that participants from the experimental group spent more time on the videos than participants from the control group, but since it is not significant the condition did not influence the playtime. The relation between age and playtime is significant, with r = -.248, p = .034. This means that older participants spent less time on the video than younger participants. The other variables are not significantly related to playtime, with the relation between pre-test score and playtime r = -.120, p = .191, and between mind wandering and playtime r = -.035, p = .399.

To see whether condition, age, the pre-test score, or mind wandering could predict the replay time, another multiple regression (stepwise) analysis was performed. Based on the results of the study (N = 55), condition is not significantly related to replay time, r = .184, p = .090. It is shown by the trend that participants from the control group replayed parts of the

video less than participants of the control group, although the condition cannot predict the replay time. The other variables were also not significantly related, with respectively the relation between age and replay time r = -.119, p = .194, between pre-test score and replay time r = -.103, p = .228, and between mind wandering and replay time r = .047, p = .368.

Again, a multiple regression (stepwise) analysis was done to see whether condition, age, the pre-test score, or mind wandering could predict the unique playtime. Based on the results of the study (N = 55), condition is not significantly related to unique playtime, r = .191, p = .081. The trend, however, shows that participants from the experimental group have reviewed more of the video than participants of the control group. The relationship was not significant between age and unique playtime r = -.208, p = .064, however, the trend showed that older participants reviewed less of the video. The other variables were also not significant related, with respectively the relation between pre-test score and unique playtime r = -.044, p = .374, and between mind wandering and unique playtime r = -.037, p = .395.

In case of replay time also the frequencies are analysed. When comparing conditions, 93.3% of the participants from the experimental group (N = 28) have replayed parts of the video at some time, while 75% of the participants form the control group (N = 30) used replay. Overall, 84.5% of the participants did not use replay anywhere in the video. To analyse whether there is a significant difference in replay frequency between the control and experimental group, a Mann-Whitney test was conducted. The test showed that the amount of mind wandering did not differ significantly between the control (N = 30, M = 31.07) and the experimental (N = 28, M = 27.82) group, U = 373.00, z = -1.30, p = .195.

4.3 Knowledge gain

For knowledge gain, a repeated-measures ANOVA was done to measure whether the score on the pre-test and the score on the post-test differ significantly. Age was used as a covariate. The assumption of sphericity has not been violated since there are only two variables. The results show that the score on the pre- and post-test did differ significantly, F (1, 55) = 68.10, p = .000. This means that the participants have gained knowledge from the videos.

A multiple regression (stepwise) analysis was done to see whether condition, age, mind wandering, playtime, replay time, or unique playtime could predict the knowledge gain. Based on the results of the study (N = 55), condition is not significantly related to knowledge gain, r = .019, p = .445. Age and knowledge gain are significantly related, r = -.279, p = .019, which means that older participants gained less knowledge than younger participants. Unique playtime and knowledge gain are also significantly related, with r = .230, p = .046. This means that participants who watched more of the video, gained more knowledge. The other variables are not significantly related, with the relation between mind wandering and knowledge gain r = .166, p = .113, between playtime and knowledge gain r = .166, p = .113, between replay time and knowledge gain r = .044, p = .376.

The mean scores of the participants of both the control and experimental groups for the pre-test, the post-test as well as the difference between them can be seen in Table 3. Also included are the scores of both groups combined.

Table 3. Mean Percentage of Test Scores and Difference of Control, Experimental and Total Group.

	N	Pre-test		Post-test		Knowledge Gain	
		M	SD	M	SD	M	SD
Control	30	12.58	12.72	39.73	16.15	27.15	11.62
Experimental	28	16.52	14.37	44.00	16.59	27.48	15.24
Total	58	14.48	13.57	41.79	16.36	27.31	13.37

4.4 Relation mind wandering and knowledge gain

To analyze whether mind wandering influences knowledge gain, a linear regression analysis was performed. The regression analysis revealed that the overall model was not significant, R^2 = .07, F (1, 32) = 2.29, p = .140. This means that mind wandering does not influence knowledge gain.

4.5 Questionnaire

A principal axis factor analysis with oblique rotation was conducted on the 12 questionnaire items. For the full table with all data, please see Appendix I: Factor analysis questionnaire items. The variable Immediate Effect was constructed with five items which explained 45.99% of the variance. Current Concerns was constructed with four items which explained 14.67% of the variance. The last variable, General Effect, was constructed with three items which explained 9.96% of the variance. To identify the reliability of the data, Cronbach's α was calculated. The results of this showed .88 for Immediate Effect, .77 for Current Concerns, and .80 for General Effect. This means that the reliability of the construct Current Concerns is acceptable while the reliability of Immediate Effect and General Effect are good.

With these newly constructed variables, a multiple linear regression analysis was performed to test whether they can predict mind wandering. The regression analysis, as shown in Table 4, revealed that the overall model was not significant, $R^2 = .11$, $F\ (3, 51) = 2.17$, $p = .103$. This means that the variables Immediate Effect, Current Concerns and General Effect cannot be used to predict mind wandering.

Table 4. Linear model of predictors of mind wandering.

	b	*SE*	β	*p*
Constant	14.10	.69		.000
Immediate Effect	-1.27	.87	-.23	.150
Current Concerns	-1.05	.80	-.18	.198
General Effect	-.04	.95	-.01	.967

Note. $R^2 = .22$.

4.6 Interviews

In this chapter, the results of the interviews are shown. Pseudonyms are used to protect the privacy of the interviewees. Four participants from the control group (Adam, James, Emma and Sophie) and four participants from the experimental group (George, Emily, Jennifer and Michael) were interviewed. Both groups included two males and two females. The youngest interviewee was 23 and the eldest 54. The interview results are shown starting with a more

general view on attention and mind wandering in general (4.6.1) Then the results will dig deeper into these topics concerning the experiment itself (4.6.2) and the attention and mind wandering during the experiment (4.6.3). The chapter ends with a paragraph about the opinion of the participants about the embedded questions (4.6.4).

4.6.1 Attention and mind wandering in general

Almost all participants mentioned that it is very important for their concentration to have a genuine interest in the content. One participant added that for him the goal in a lecture is to gain knowledge. *"If I understand something and then a very boring example is given or they have to explain it again … then I mind wander."* Mind wandering can be caused through something external, like Adam stating that social media can be a big distractor for him. Causes can also be more internal and based on people's current concerns. While one mentioned that she mind wanders more often when she feels stressed, another added that she mind wanders when she is tired or when she is busy and thinks about all the things she needs to do. Michael stated that he could imagine that people would mind wander more when they have a lot of things going on, however, he does not recognize that in own experiences. George's answers are in line with Michael's: *"I would say, logic would lead to me saying yes [more mind wandering when having a lot on your mind], however, I cannot connect this to my experience from the video"*. This could be explained by Emma, who stated that current concerns like "*stress"* or "*sleeplessness*" might influence the amount of mind wandering, but doesn't think it is as big of an influence as the earlier mentioned interest in the content.

To battle mind wandering, it differs what the participants do. Some are aware of their attention already during their scheduling. Both Emma and Michael state that they have better concentration in the morning and therefore often plan their study time then. Emma admits that even then she could lose her concentration, but those were her more "*productive"* hours. Others have measures for during the studying itself. George states that to have good concentration, he needs to stay hydrated. Adam told about some precautions he takes against mind wandering: "*You see my desk here, I will describe it. I put my desk against the wall with hardly any external stimuli around me. …. I have to really isolate myself."* Since he was aware that social media is one of his biggest distractions, he also had an app installed on his phone with which he could disable everything on his phone for an

hour. To keep her attention on the lecture, Sophie types along with the lesson. She noticed that it was harder to concentrate during this experiment because she didn't type with the lecture this time. There is also more general prevention of mind wandering by practicing. Jennifer has been more aware of her mind wandering lately and to battle it, she tries to practice keeping her focus on the task for a longer period. She states that she experiences improvements in for example awareness: "*I am more aware of 'oh, I am not thinking about that anymore'. Then it is easier to say to yourself like: 'you have to go back'."*

The general feelings of participants about mind wandering were sometimes negative, as one of them mentioned to have felt like: "*What have I been doing here [in a lecture], I have only been mind wandering*.". Another participant even looked at mind wandering as something that results in a punishment, by saying "*The punishment is that you have to go home and in case of a lecture you have to read your book a bit more attentive*". Although not in a lecture environment, Jennifer expressed that while she feels neutral about mind wandering in general, it does bother her when she is talking to other people and misses parts of the conversation.

However, despite these negative sides to mind wandering the overall feeling connected to mind wandering was, for most participants, neutral. This showed in statements such as "*To be honest, I don't really care"* and *"What [mind wandering] does to me? Not much".* In some cases, the feelings toward mind wandering were even positive. James answered that he found mind wandering okay. He stated the following: "*I think [mind wandering] is okay. I don't miss any information that I would have wanted to know. Or, in principle, yes, but I would not have found it interesting.*". Liam even quantified mind wandering as being 'relaxed'. "*I don't really mind it at all.*" The feelings mentioned in this research are therefore not in line with the findings from the research mentioned above.

4.6.2 The experiment

Most of the participants stated that they found the video lesson interesting. While the content was new for some, for others it was more of a refresher or repetition since they already had learned some from history lessons during middle school of from television shows. Especially for the participants for whom the information was unfamiliar, the lesson had some parts that were harder to follow. Jennifer even said that she "*kind of dropped out of the lesson when the content was really hard to understand*".

The opinion of the participants about the lecturer was mixed. Michael, for example, said that he found the lecturer "*clear*" and "*easy to understand*". Jennifer agreed and stated that *"really understands the subject matter and she wants to transfer [her knowledge]"*. She adds, however, that there are also some points for improvement. One of those points of improvements were brought by James, who stated the following about the lecturer and the lesson: *"I thought she was a bit slow. A bit quicker, a bit more enthusiastic, a bit nicer told and then I would have found it nicer.*" Emily said that the lecturer could talk more smoothly by stating less 'uhh..'. When asked, she answered that the thinks the non-fluency did have a negative influence on her concentration. She added: "*I think that if someone can tell it very concise and fascinating, it would be different."* Adam went even further than that by stating the lesson was "*boring*" and "*tedious*" which caused him at some points to "*be distracted by other things than the lecture*" or, in other words, caused him to mind wander.

4.6.3 Attention and mind wandering during the experiment

Most of the participants mentioned that the level of interest in the content influenced their (in)attentiveness. James stated that he found the content in the beginning interesting and that his attention then was better than later on. Adam said that him finding the subject interesting made it easier to concentrate. It differed a lot per participant what parts of the lecture made them attentive and what parts made them mind wander. Adam and George both stated that they started mind wandering when the teacher would not be to the point and she was giving examples. Emma, however, stated: "*the part where I could pay attention more easily, was a sort of example from practice … which was less theoretical and more visually enhanced".* What also differed per participant is the moment in time when they mind wandered more. While James said his concentration got less over time, Jennifer stated that her concentration was really bad at the beginning, and Emma found her concentration not great at the beginning and the end while it being better in between.

Jennifer mentioned external causes like her boyfriend walking through the house which made her look away from the screen. She also was trying to figure out how the website worked with the videos and how many videos there were, which distracted her from the task. Besides external causes, Jennifer also mentioned personal causes. Since half a year she has been working on her concentration, which made her very aware of her own (in)attentiveness in this experiment. Emily found causes of her mind wandering also

personal by stating: "*I did not find [my concentration] very optimal. It did not have anything to do with the lesson per se, because I found it quite interesting, but it has more to do with myself having trouble to really concentrate at the moment."*

Parts of the experiment that had nothing to do with the lesson itself also influenced the concentration of the participants. Some said that the probe itself, the beep, helped their concentration. *"The funny part was that the beep in between gave me a lot of time to start attending the lesson again",* said Adam. Michael mentioned that it might have influenced his mind wandering that he knew what the experiment was about. "*I did get what the intention of the experiment was, so it might have been that this in my subconsciousness has led to me trying extra hard."*

4.6.4 Embedded questions and difference between conditions

When asked, the participants from the control group (who did not have embedded questions during the experiment), all mentioned that they thought embedded questions would help with their concentration. Emma mentioned that she thought the embedded questions would give her more of a feeling of being tested. Sophie suspected that the embedded questions would have even more influence on her concentration if she would know upfront that the questions would come. She said: *"Because at a certain moment I thought like, oh, maybe I will receive questions afterwards, and then I automatically started to remember more answers and repeat them in myself for a bit"*.

These predictions are in line with the feelings of the experimental group. Some participants confirmed the idea of Sophie that it would be good to know upfront that there will be embedded questions. Statements like: "*I have to confess that the first video that I saw – then you don't see the question – I was thinking like, huh, do we have two videos or how does this work…?"* and *"How does this work. … I had to explore everything"*. These statements demonstrate the confusion the participants had in the beginning. Michael mentioned that he started paying more attention once he understood the mechanic of the embedded questions. He thus started paying more attention only after the first round of embedded questions and during the second video, while maybe with a clear instruction upfront he would have had that extra attention in the first video already. The initial confusion aside, most participants were positive about the embedded questions. George said that they gave him stimulation to pay attention. Emily stated that she predicted it would

be different to have embedded questions from only having questions at the end. She said: *“Then you know that immediately after [the video] you will receive a question and that you think like ‘oh yes, I have to pay attention, in a moment I will receive a question’”*.

Not only did the embedded questions made them realize they should pay attention. Jennifer mentioned for example that the embedded questions also helped her by giving her a little ‘break’ from watching the video. She liked to do something instead of having to go watch the next video immediately. A connection can be drawn to George who answered that his focus is best when he feels like he can add something or contribute to the whole. The embedded questions also helped to process the newly learned information. Jennifer says about the embedded questions: *“Well, I found them kind of nice, since then you think back about what you heard”.* Emily extended this by stating: “*I think they are great because then you repeat already the things you need to remember”.*

5 Discussion and conclusion

In the discussion, the theoretical framework will be revisited and compared to the results of the current research. This way the research questions will be answered. First, the three sub-questions will be answered, starting with the effect of embedded questions in recorded lectures on both mind wandering and knowledge gain respectively. After that, the relationship between mind wandering and knowledge gain will be analysed. Ultimately these three parts should help answer the question: What is the effect of embedded questions in recorded lectures on mind wandering and knowledge gain?

After the comparison of existing theory and results of the current study, the limitations of this study will be shown followed by the scientific and practical relevance. This chapter will conclude by giving some suggestions for further research.

5.1 Mind wandering in a natural situation

As this study is one of the first to look at mind wandering in a natural situation, it is important to start with looking at what mind wandering is like. A study by Killingsworth and Gilbert (2010) predicts that people mind wander around 40% of the time. The mind wandering in this research was similar, with 43,82%.

The hypothesis of current concerns (Klinger, Gregoire, & Barta, 1973, in Smallwood, 2013) as a cause of mind wandering is supported by the qualitative results of this study. As stated before, the current concerns hypothesis suggests that people will mind wander when the task itself is not stimulating enough. Most of the participants stated that one of the most important causes of mind wandering is not finding the content interesting. One interviewee also mentioned that parts when the lecture was *"boring*" or "*tedious*", he mind wandered. The current concerns hypothesis also suggests that learners will mind wander when they have more prominent off-task stimulation like goals or yearnings. This too was supported by this study. Participants answered that they mind wandered more often when they feel *"stressed*", "*busy*", or think about all the things they need to do. If these thoughts are pressing and the lesson is not interesting enough, mind wandering might become unavoidable.

5.2 The effect of embedded questions on mind wandering

As stated in the theoretical framework, the world nowadays is full of distractions for learners (D'Mello, 2016; Risko et al., 2013). This has been confirmed by one of the participants, who said that social media for him is one of the biggest distractors. This means that learners have to be capable of steering their attention away from those instructions to the learning materials. Research has shown that embedded questions might be able to help here since they have a positive effect on mind wandering (Schacter & Szpunar, 2015; Szpunar et al., 2013). Szpunar et al. (2013) showed that embedded questions in a video lecture lead to more on-task attention and less mind wandering. It was therefore expected that the participants with embedded questions would mind wander less than the participants without embedded questions. This expectation was, however, not met. The current study showed that adding embedded questions to a video lecture does not need to decrease the learners' mind wandering.

Embedded questions which capture attention, allow reflecting and allow correcting knowledge shortfalls should be able to combat (the effects of) mind wandering (D'Mello, 2016; Szpunar et al., 2013). If the embedded questions capture the attention of the learners, it would show in less mind wandering during the experiment. As stated, this is shown in the quantitative results of the current research. During the interviews, however, some of the participants mentioned that the embedded questions had a positive effect on their concentration. For example, one participant stated that: "*Then you know that immediately after [the video] you will receive a question and that you think like 'oh yes, I have to pay attention, in a moment I will receive a question'".* Regarding the opportunity to reflect on the content, the opportunity was there. The embedded questions were directly below the segments, so participants had plenty of time to go back and search for the answers in the video. However, hardly any learners made use of this opportunity, with 84.5% not having replayed even only a part of the video. This might be due to the participants missing a good incentive to really learn the video content. In section 5.7 Limitations more will be explained about the incentives of the participants. The last goal an embedded question should have is the opportunity to correct knowledge shortfalls. Like with reflection, there were opportunities enough. Learners who read an embedded question and didn't know the answer could go back to the video (which was on the same page as shown in Appendix B:

Impression embedded questions) and search for the answer. Although the option was there, again learners did not go back to the video to search for the answer.

5.3 The effect of embedded questions on knowledge gain

The theory states that the testing effect can improve retention of the material even more than additional study would (Roediger III & Karpicke, 2006). One of the beneficial properties of embedded questions is that they can cause the testing effect. This is because they make learners retrieve information from memory. This is confirmed in the interviews, where some participants stated that the embedded questions are great, because *"then you repeat already things you need to remember"* and "*…since then you think back about what you heard"*. However, this theory is not supported by the quantitative part of the current study. Learners who had embedded questions during the experiment did not learn more from the video lecture than learners who had not embedded questions. Thus, although people feel like it helped them, they did not perform better on the test afterwards.

5.4 The relationship between mind wandering and knowledge gain

Many pieces of research have shown that mind wandering can have very detrimental effects on the learning process of students (Bixler & D'Mello, 2015; D'Mello, 2016; Risko et al., 2012). Mind wandering can cause poorer memorization of the lesson and the absence of important knowledge. This can lead to worse retention of the lecture and the learner to make mistakes. Randall et al. (2014) go even further than that by stating that there is a consistent negative relationship between mind wandering and task performance. This was also shown by Szpunar et al. (2013) who argued that embedded questions in a video lecture can directly lead to less mind wandering and through that indirectly lead to better scoring on a final test. It was therefore expected that mind wandering would influence the knowledge gain in the current research. However, the results show the neutrality: there is no relationship between the amount of mind wandering and the amount of knowledge gain.

As stated, the results of this research are do not support what most studies say. The results are, however, in line with the results of a study by Randall (2015) who also did not find a negative relation between mind wandering and task performance. It is stated by Randall that a possible explanation as to why there is no relationship found between mind

wandering and task performance might be that there was a relatively low amount of mind wandering during their research. That cannot be an explanation for the lack of a relationship in the current research since the students' mind wandered with a total mean of 43,82% compared to the expected 40% by Killingsworth and Gilbert (2010). The participants were asked to avoid mind wandering and they had to report their mind wandering levels during the experiment. It might have been that this influenced the attention regulation in the research of Randall (2015). In the current research, the participants were not asked to avoid mind wandering. They were, however, quite aware of the fact that 'mind wandering' was an important aspect of the research. One of the interviewees said: "*I did get what the intention of the experiment was, so it might have been that this in my subconsciousness has led to me trying extra hard".* The experiment itself has affected the mind wandering of the participants, as one of the participants stated: "*The funny part was that the beep in between gave me a lot of time to start attending the lesson again"*.

5.5 The effect of embedded questions on mind wandering and knowledge gain

As shown in the theoretical framework, research has shown negative effects of mind wandering of an emotional as well as a factual nature. Regarding the emotional nature, Killingsworth and Gilbert (2010) have shown that people are generally less happy when mind wandering than when they are not. To see whether the current research can also prove that statement, the interviews were revisited. The participants in this research do have some negative feelings toward mind wandering. However, they are mostly neutral by stating "*I don't really mind at all*" or "*I don't really mind it at all*". One participant even finds mind wandering *"relaxed*". The findings of this research thus are not in line with the above-mentioned theory.

Regarding the factual nature, it was expected that a negative relationship between mind wandering and the knowledge gain would be found, since that has been the consensus in research so far (Bixler & D'Mello, 2015; D'Mello, 2016; Randall et al., 2014; Risko et al., 2012; Risko et al., 2013; Smilek et al., 2010). In the current research, however, it was shown that mind wandering does not predict knowledge gain. Learners who mind wandered more, did not learn less than learners who did not mind wander as much. Although this is not in line with the existing consensus, it is in line with the research of Randall (2015), who also did

not find a significant negative relationship between mind wandering and performance on a task afterwards. More research in this field is therefore needed.

5.6 Scientific & practical relevance

Research has shown the detrimental effects of mind wandering during video lectures (Risko et al., 2013). Although the addition of embedded questions looks like a promising way to improve the effectivity of video lectures, there has not yet been systematic research whether embedded questions can also help reduce mind wandering (Schacter & Szpunar, 2015). Szpunar et al. (2013) state that positive effects of embedded questions on mind wandering have been found. However, they also add that these experiments were only a first step and that it needs to be explored further, which is the goal of this study.

Other than extending the existing research, the outcomes of this research is advice to practitioners how to make their recorded lectures more effective. This research showed with the interview results that the participants' attention span was more influenced by the video itself (content or lecturer) than other influences (like stress or distraction from other people). It can, therefore, be stated that it is very beneficial for practitioners to invest time and money in developing a good video lecture, because it does make a difference.

5.7 Limitations

The probe-caught method as a way of measuring mind wandering is quite subjective. Although many studies use it, people in the interviews told that they found it hard to know whether they did or did not mind wander. This also shows in the data: there are quite some times where people either filled in too few or too many yes/no answers. It is therefore important that this kind of research should be redone with more objective measures such as sensor technology. The fact that participants could fill in the wrong amount of yes/no answers was also due to the fact that this study tried to show mind wandering in a realistic environment. Participants could participate in the experiment at home, in an environment where they would normally study. While this is very new in this field, it also had less control from the researcher than the same research in a laboratory setting would have had.

Another limitation of the current study is that although it mimics a realistic study environment, it did not provide a representative incentive. Normally when students learn,

they want to pass a course, get a diploma or choose the topic out of genuine interest. This was not the case in this research. Some participants might not have interest in law at all and have participated for a different incentive, for example, to help the researcher, for a coupon, or to gather research points of the UTwente. Since most learners in the interview mentioned that it is very important for their concentration to have a genuine interest in the content, this might have resulted in a higher percentage of mind wandering than they otherwise would have had. On the other hand, however, participants knew that they were participating in an experiment. One of the participants stated: "*I did get what the intention of the experiment was, so it might have been that this in my subconsciousness has led to me trying extra hard"*. Therefore, this could have led to less mind wandering which balances the before mentioned higher percentage.

5.8 Future research

As stated before, for more objective measuring of mind wandering one might repeat this study with sensor technology like eye-tracking or physiological measurements to get a more objective measure of mind wandering. Another suggestion for future research is that the effect of embedded questions on mind wandering and knowledge gain should be researched while adding feedback to the embedded questions. As stated, for the testing effect to take place, feedback is not necessary (Roediger III & Karpicke, 2006). Therefore, feedback was omitted during this experiment so the experimental group would not be exposed to any extra information. However, it would be interesting to research whether the feedback would make a difference in this research.

As stated during the introduction, recorded lectures should be as effective as possible (Schacter & Szpunar, 2015). As mind wandering is a well-known threat to that effectiveness and embedded questions had shown some initial potential to combat mind wandering (Gilboy et al., 2015), the goal of the current study was to research what the effect of embedded questions is on both mind wandering and knowledge gain. If this research would have confirmed the initial results of Szpunar et al. (2013) that embedded questions indeed are an effective means to combat mind wandering and increase knowledge gain, research would be closer to reaching consensus. However, this is not the case. Like the findings of Randall (2015), the results in the current study are opposite from the expectations. As in new and innovative ways of learning (MOOCs and Flipped Classrooms) video lectures are

fundamental, it is important to find out how to use them to their maximum potential. To reach that, more research is key.

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7 Appendices

Appendix A: Form reporting mind wandering

Did I mind wander?

Segment 1

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Segment 2

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Segment 3

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Segment 4

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Segment 5

	Yes	No
Probe 1		
Probe 2		
Probe 3		
Probe 4		
Probe 5		
Probe 6		

Appendix B: Impression embedded questions

Appendix C: All embedded questions

1. What is jurisprudence?
2. Why does a minister need a law on kilometre charges to carry out kilometre charges?
3. Which jurisdictions are part of public law? And what do these entail?
4. Why is it funny that Fokke and Sukke address the recorder with “Members of the jury…”?
5. What does the executive power encompass? Give an example.

Appendix D: Probe-placement procedure

To decide where in the videos the probes should take place, an online randomizer was used from https://www.randomizer.org/. Every minute (0:00-1:00, 1:00-2:00 etc.) of every segment, there should be one probe. For every segment, six random numbers between 0-60 were generated, which stand for the seconds within the minute. For segment 1 for example, the following numbers were generated: 10, 19, 25, 56, 35, 57. For every segment it was checked whether the probe would fall within the video or not. Since segment 1 is for example only 05:24 long, the last number will be deleted from the sequence. The probes outside of the length of the segments are shown in red in the table below and will not be used.

The next step was to put the seconds mentioned in the sequence to the corresponding minutes. The first number stands for the seconds within the first minute, the second number for the number in the second minute, etc. For segment 1 this means that since the first numbers in the sequence are respectively 10 and 19, the first probe will take place at 0:10 and the second probe will take place at 1:19. This procedure is then repeated for every segment, resulting in the table below:

Segment	*Total:*	*0:00-1:00*	*1:00-2:00*	*2:00-3:00*	*3:00-4:00*	*4:00-5:00*	*5:00-6:00*
1	**05:24**	0:56	1:19	2:25	3:56	4:35	~~5:57~~
2	**04:03**	0:40	1:53	2:21	3:06	~~4:24~~	~~5:27~~
3	**04:46**	0:48	1:47	2:17	3:03	4:18	~~5:10~~
4	**04:51**	0:55	1:29	2:06	3:18	4:11	~~5:25~~
5	**05:55**	0:48	1:42	2:55	3:45	4:13	5:16

Since the first probes come really soon into the video, the participant is likely to fill in 'no' when asked if he/she has been mind wandering since the participant has had hardly any chance to wander off with their thoughts. It was therefore decided that the first probe for segments 1, 3, 4 and 5 (who's probes were respectively 0:10, 0:05, 0:21, 0:09) are rerolled so that it is made sure they will appear in the second half of the first minute. The new values

can be seen in the table above. For the same reason the third probe of segment number 3 was rerolled, since there were only six seconds between that and the next probe which leaves the participant no time to mind wander. The third probe was changed from 2:57 to 2:17.

Now the timing of the probes has been decided, the probes are added to the videos. Each probe consists of a standard audio tone from the Apple software iMovie called “computergegevens 01”. For each probe, the moment it should appear can be seen in the table above. However, to make sure the probe disturbs the video the least as possible, a good moment for the probe was found close to the timing given in the table. A good moment can for example be when the teacher takes a breathing pause or between two sentences.

Appendix E: Questionnaire

1. Na het bekijken van een les op video snap ik de inhoud goed.
   After watching a video lesson, I understand the content well.
2. Na het bekijken van een les op video ben ik de inhoud snel vergeten.
   After watching a video lesson, I soon forget the content.
3. Een les op video is voor mij niet zo leerzaam.
   A video lesson is not that informative for me.
4. Een les op video is voor mij een goede manier om kennis op te doen.
   A video lesson is a good way to gain knowledge for me.
5. Een les op video is voor mij niet zo effectief.
   A video lesson is not that effective for me.
6. Tijdens het bekijken van een les op video neem ik veel informatie op.
   While watching a video lesson, I take in a lot of information.
7. Tijdens het bekijken van een les op video kan ik mij goed concentreren.
   While watching a video lesson, I can concentrate well.
8. Tijdens het bekijken van een les op video denk ik aan persoonlijke dingen die niets met de les te maken hebben.
   While watching a video lesson, I think about personal stuff that have nothing to do with the lesson.
9. Tijdens het bekijken van een les op video dwaal ik af als ik veel dingen te doen heb.
   While watching a video lesson I mind wander when I have a lot of things to do.
10. Tijdens het bekijken van een les op video dwaal ik af als ik gestresst ben.
    While watching a video lesson I mind wander when I am stressed.
11. Tijdens het bekijken van een les op video dwaal ik af als de inhoud moeilijk te begrijpen is.
    While watching a video lesson I mind wander when the content is hard to understand.
12. Tijdens het bekijken van een les op video verlies ik gemakkelijk mijn concentratie.
    While watching a video lesson I lose my concentration easily.

Appendix F: Interview

All questions are translated from Dutch.

1. What did you think of the lesson?
2. How did you find your concentration while watching the video? *Is that similar to normal? Or would you normally have better/worse concentration?*
3. Control: What would you think of having questions in between the segments? *Would that have influenced your concentration?*

   Experimental: What did you think of the questions in between the segments? *Do you think they influenced your concentration?*
4. What is your definition of mind wandering? *Task related versus not-task related, internal vs external, being distracted, …*
5. When do you mind wander? *Is that when you are personally busy, if the lesson is giving you a lot of stimulus, is the lesson is not interesting …*
6. Are you a person who mind wanders a lot? Do you normally have good concentration?
7. Do you sometimes do something to combat mind wandering? *Do you do something before you start the activity (like mindfulness)? Do you do something during the activity (like taking a break or drink coffee)?*
8. How do you notice you mind wandered? Do you feel like you notice it quickly when you mind wander? *Or does it take some time or even a while until you notice?*
9. If you mind wander, how do you feel? *How disturbing/bad do you find mind wandering?*
10. When you notice you mind wandered, what do you do?
11. Do you sometimes have good focus? If yes, how come that you have good focus that time as opposed to other times.

Appendix G: Pre-test

Translated from Dutch.

1. What is meant by the legalistic approach of law? (3 points)
2. What is a better approach of law than the legalistic approach? Provide explanation. (2 points)
3. What is jurisprudence and what does it mean that it is authoritative? (2 points)
4. Law has a protective function. What does this mean? (1 point)
5. Law has next to the protective function, also an instrumental function. What does this mean? (1 point)
6. Imagine that the councillor of spatial planning only provides building permits for houses with green window-frames. Is the councillor allowed to do this? Explain why yes/no. (3 points)
7. Law exists of private law on the one hand and public law on the other. Explain what the differences are between the two. (2 points)
8. Rita sues her neighbor because he had built a fence that is too high. What type of law applies to this? (1 point)
9. What is a democratic constitutional state? (2 points)
10. In the Netherlands we have separation of powers. Explain how the separation of powers works in the Netherlands. (maximum of 3 points)

Total: 21 points

Appendix H: Post-test

Translated from Dutch.

1. What is meant by the positivistic approach of law? (3 points)
2. In your opinion, what is the best approach of law and why? (2 points)
3. What is jurisprudence and what does it mean that it is authoritative? (2 points)
4. What are the two mentioned functions of law and what do these entail? (3 points)
5. Only building plans for dormers with a width of four meters get a permit from the councillor of spatial planning. Is this allowed? Why yes/no? (3 points)
6. What is the difference between public and private law? (2 points)
7. The government sues Jan because he drove too fast. What type of law applies in this situation? (1 point)
8. Name two reasons why it is funny that Fokke and Sukke address the clerk with *"Members of the jury…"*? (2 points)

9. What is a democratic constitutional state? (2 points)
10. In the Netherlands we have separation of powers. Explain the separation of powers in the Netherlands. (maximum of 3 points)
11. What does the executive power entail? Give an example. (2 points)

Total: 25 points

Appendix I: Factor analysis questionnaire items

Factor Loadings Resulting from a Principal Component Factor Analysis Using Oblique Rotation (N = 58).

Item	Factor loadings: Immediate effect	Current concerns	General effect
While watching a video lesson, I take in a lot of information.	**-.819**	.196	-.261
While watching a video lesson, I can concentrate well.	**-.816**	-.228	.025
While watching a video lesson I lose my concentration easily.	**.619**	.364	-.010
A video lesson is a good way to gain knowledge for me.	**-.608**	.080	-.271
After watching a video lesson, I understand the content well.	**-.478**	.039	-.340
While watching a video lesson I mind wander when I am stressed.	-.060	**.809**	.013
While watching a video lesson I mind wander when I have a lot of things to do.	.252	**.667**	-.012
While watching a video lesson I think about personal stuff that have nothing to do with the lesson.	.414	**.568**	-.023
While watching a video lesson I mind wander when the content is hard to understand.	-.174	**.474**	.338
A video lesson is not that informative for me.	.085	-.029	**.746**
A video lesson is not that effective for me.	.117	.186	**.727**
After watching a video lesson, I soon forget the content.	.085	-.003	**.619**
Eigenvalues	5.52	1.76	1.20
% of explained Variance	45.99	14.67	9.96
α	.88	.77	.80