Student engagement in biomedical courses
studies in technology-enhanced seminar learning

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Student engagement in biomedical courses studies in technology-enhanced seminar learning

Student betrokkenheid in biomedische cursussen onderzoek naar de bijdrage van onderwijstechnologie in kleinschalig onderwijs

(*met een samenvatting in het Nederlands*)

Proefschrift

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Chapter 1

General introduction and thesis outline

Introduction

Academic medical and biomedical curricula are designed to educate future academics contributing to new developments in science, clinical practice or society. During undergraduate programs student training is typically focused on acquisition of knowledge and understanding of these interdisciplinary fields, and to apply and analyze this knowledge and understanding during theoretical or programmed lab sessions and early clinical encounters[1-3]. Graduate education programs are focused on analyzing and evaluating self-generated research data in the context of the scientific literature, and if possible expand this to the production of original work and on acquiring clinical practice[4,5]. To obtain the desired cognitive development, academic medical and biomedical undergraduate curricula are mostly occupied by a sequence of theoretical courses with some experimental training, while in graduate curricula, clinical placements and research projects are dominant, supported by theoretical courses. In the context of this thesis, we will focus on the theoretical part of undergraduate medical and biomedical curricula: classroom courses.

In most courses students are exposed to large amounts of information that need to be studied in order to successfully pass end-of-course exams. After this examining of competence, students move to a subsequent course, which usually addresses a new topic. Curriculum developers select and arrange the topics such that students can build up knowledge and that all relevant information is offered once students graduate. This is rather easy if curriculum developers know the bigger picture. However, students are not familiar with this bigger picture and often aim to pass course by course with the best possible marks. Knowing the factual information seems sufficient to achieve this short-term goal, but just passing the exams does not necessarily fulfill criteria set by curriculum developers[6]. To achieve curriculum goals, a more thorough understanding of the content is required. Optimizing the application and retention of knowledge and skills is one aim of higher education[7-9]. Applying knowledge and developing skills are examples of higher-order thinking activities[10,11]. Research findings suggest that simply transmitting knowledge in large lecture theatres is not the best way to promote higher-order thinking[7,12]. Changing passive teacher-centered education to more student-centered approaches is therefore recommended[13,14]. Examples of student-centered approaches are small group learning, problem based learning, and team based learning[15-17]. These student-centered approaches are all characterized by active engagement and participation of students. Active participation of students is known to promote learning and improves students' ability to process information and their level of

understanding[18,19]. These improvements may reflect as increased performance on summative examination or an increased retention of knowledge or both[20].
It is suggested that education will be more engaging and attractive to students when it resembles their day-to-day activities, for instance when electronic or online learning (e-learning) is incorporated in their education[21,22]. The combination of online learning and face-to-face education is known as technology-enhanced or blended learning[23-25]. Garrison and Vaughan (2008) described the basic principle of blended learning as; '*face-to-face oral communication and online written communication are optimally integrated such that the strengths of each are blended into a unique learning experience congruent with the context and intended educational purpose'* (p.5)[26].

In order to design an effective blended learning environment, a divers set of educational models can be applied[27]. These educational models originate from different perspectives and can be grouped in three categories; associative, situative and cognitive models. Associative models perceive learning as an activity. An example of an associative learning design model for student-centered and technology-rich environments is RASE[28]. This model is focused on four components, i.e. Resources, Activities, Support and Evaluation[29]. Due to this focus RASE is a rather practical model.
In contrast to associative models, situative models consider learning as a social practice. An example of a situative model is Wenger's communities of practice[30]. A community of practice is characterized as a group of people who identify themselves by sharing a domain of interest. Members of this group regularly interact and learn together and the group develops a shared practice, for instance a repertoire of experiences or tools.
The third category involves cognitive models that regard learning as achieving understanding. An example of a pedagogical model with a cognitive perspective is the *Community of Inquiry* framework. The community of inquiry framework is aimed at engaging students in deep and meaningful learning[31,32]. Moore and Keasley described that engaging learning environments typically include three types of interactions: (1) Learner-content, (2) Learner-instructor, and (3) Learner-learner interaction[33]. These three interactions were introduced to blended learning environments by Garrison and coworkers[31]. Since the cognitive perspective corresponds with the previously mentioned curriculum goals, the community of inquiry model will be discussed in more detail.

Community of inquiry

The concept of community of inquiry (CoI) was originally developed by the pragmatist philosopher John Dewey, and addressed the nature of knowledge formation and the process of scientific inquiry in research communities[34,35]. Later, the concept of CoI was applied to many other contexts, including educational experiences. In the educational context, the theory of CoI is grounded in two essential elements of higher education, which are 'community' and 'inquiry'. Community is characterized by the "*recognition of the social nature of education and the role that interaction, collaboration, and discourse play in constructing knowledge*". "*The process of constructing meaning through personal responsibility and choice*" is known as inquiry[26].

In a CoI learners form a cohesive and interactive community with the purpose to analyze and construct meaningful knowledge[26,36]. CoI is based on three interacting domains: cognitive, teaching and social presence[37] (Figure 1). The word *presence* must be interpreted as the perception of representation and not only as physical occurrence. Each domain of CoI will be discussed in more detail below.

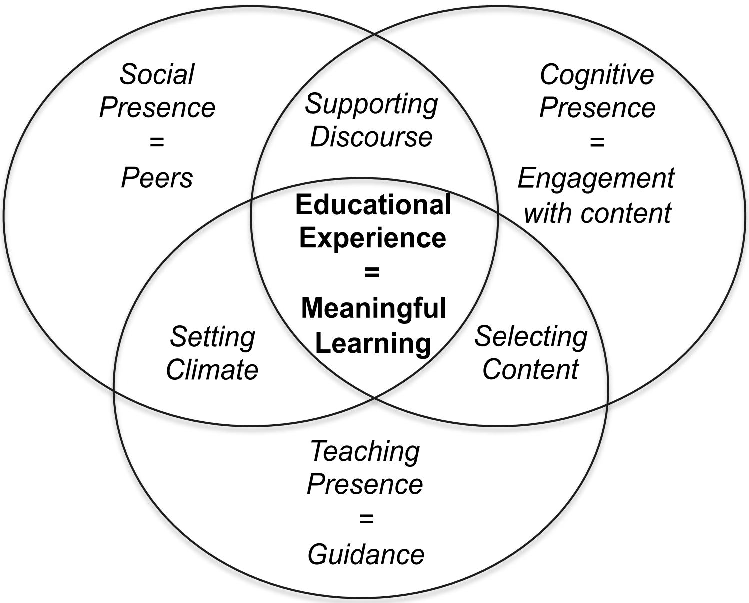

Figure 1. Three domains that comprise the community of inquiry are Social, Cognitive, and Teaching presence. Interpretation of each domain is shown. The interaction of all three domains is needed for meaningful educational experiences (adapted from Garrison et al.2004).

Cognitive presence

Cognitive presence is based on the critical thinking literature[38] and involves creative thinking, problem solving and gaining insight[26] and ultimately results in deep learning, meaningful understanding and acquisition of skills[39]. In critical thinking four phases are distinguished; a trigger event, exploration, integration and resolution.

In education, the trigger event is often encrypted in an assignment or learning task. In order to solve the learning task, students first need to gather more relevant information. Exchanging information during brainstorm sessions and questioning may lead to information that can be constructed into meaningful ideas. In the end these steps should result in consensus among students and a solution to the learning task. In blended learning, interactive online learning tools might trigger students' attention, whereas subsequent homework activities or in-class discussions might lead to possible solutions. In the context of this thesis cognitive presence is interpreted as active engagement of individual students with the course content.

Teaching presence

Teachers play an important role in the process of critical thinking and their role is not restricted to in-class activities. Actually, this so-called 'teaching presence' can be divided into three categories: design and organization, facilitation discourse and direct instruction[40].

Teaching presence starts with the design and organization of a course (*selecting content* in Figure 1). In this category teachers create course materials, design individual and group activities, provide student with tips and guidelines and model effective use of course materials.

Once the course has started, teachers can stimulate students to participate in many ways. Both in face-to-face setting and in online learning, teachers can encourage students to respond in discussions, comment on other students' input in discussions and model appropriate student behavior (*Setting climate* in Figure 1). This may positively influence students' interest, motivation and engagement in active learning[40]. Finally, teachers can provide students with clear study directions, meaning they direct students to learning resources, give them feedback, provide leadership, share knowledge and help students to construct information in their minds. Teaching presence is an important factor for student satisfaction, perceived learning and a sense of community[37,41]. In this thesis, teaching presence involves guidance on students' learning process and mostly consists of face-to-face or online feedback.

Social presence

The third domain required for deep and meaningful learning and another important resource for support is found within peers. Within a course, peers are likely to share identical learning goals and are therefore suitable partners to communicate, interact and identify with[37,42]. Cohesion of a group is sometimes referred to as social presence, and is relatively easy to establish in face-to-face and online synchronous education. In asynchronous online learning environments this is more difficult[43,44]. Social presence is the mediating factor between cognitive and teaching presence and consists of three aspects; effective communication, open communication and group cohesion[38]. Critical thinking is supported by social presence (*Supporting discourse* in Figure 1), because a sense of cohesion makes group interactions more appealing, engaging and intrinsically rewarding[45]. The sense of group cohesion, also known as relatedness, is known to positively influence intrinsic motivation of students[46-48]. Both intrinsic motivation and group cohesion are beneficial for learning outcomes, as it reduces student dropout[49]. In contrast, Kaba et al. debated that group work does not always result in better outcomes, as brainstorming may also lead to group conformity bias and fewer ideas[50]. Every ability to connect and discuss with peers is regarded social presence in this thesis.

Blended Learning

Following the community of inquiry model, new opportunities for effective educational experiences appeared with the introduction of blended learning. Blended learning has become an umbrella term for many combinations of e-learning and face-to-face-learning[51]. Some of these combinations may be more e-tool based, such as standardizing the recording of (live) lectures and making them available as online lectures to students[52] or offering online formative assessments to students[53]. Others follow a didactic approach by careful design and application of a flipped classroom approach. Each of these blended learning approaches will be further introduced below.

Online lectures

Online lectures mainly originate from two resources: recordings of (live) lectures or existing videos, usually available on the Internet, that teachers re-use, such as YouTube-videos. According to Pluck and Johnson, students are provided with videos to stimulate their curiosity[54,55]. Others have demonstrated that videos are used as a resource complementary to live lectures. Students often use videos to complete lecture notes, or to rehearse the content before the exam[25,52,55,56]. Pilarski identified that online videos reduce stress and test anxiety for students[57].

The advantage of online videos is the fact that they can be paused, rewinded or fast-forwarded, which is not possible with an actual professor[55,56 ,58]. Videos are also appealing to students because they can be watched anytime and anywhere the student prefers[56]. Overall, online lectures provide students with more flexibility compared to live lectures[59]. The effect of online videos on classroom attendance is still being debated. Some state that students prefer to visit lectures[57], while others have noticed that some students stopped attending them, once online videos were available[60,61].

Online formative assessment

Another frequently use e-learning tool is online formative assessment. In contrast to summative assessments, aimed to judge student performance with a mark after the learning process, formative assessments aim to provide students feedback during the learning process (Figure 2)[62,63]. This feedback provides students with insight into their level of understanding[28,64] and helps them to identify gaps in their knowledge. With this type of self-assessment student can transit from knowledge acquisition to cognitively complex levels of knowledge application. Several studies have shown that formative assessments enhance motivation to learn and improve achievements[65-68]. Figure 2 shows the different relationships between assessment and learning[69].

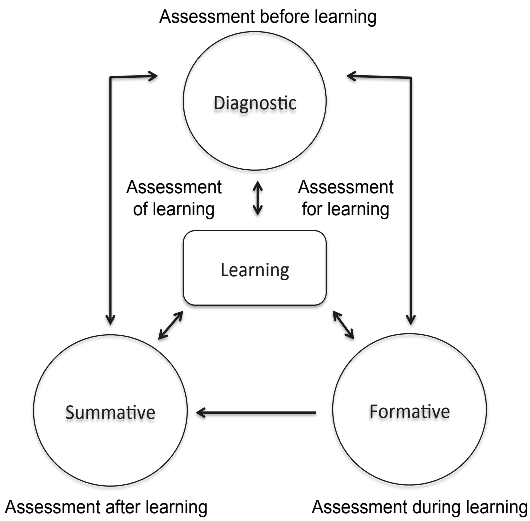

Figure 2. Types of assessment (redrawn from Crisp, 2007).

The formative assessments are not only useful for learners themselves, also teachers can benefit from students taking these tests when used as a diagnostic tool. If the majority of students struggle with the same test items, this topic may not be clear to them. Teachers might address this information differently or in more depth in subsequent classroom sessions. Together teachers and students might be able to close the knowledge gap[66,70].

Flipped classroom

The introduction of blended learning has inspired educators to rethink their education. Several authors have suggested moving information transfer, which is traditionally done in lectures, outside the classroom[21,71-75]. This didactical approach of blended learning allowed teachers to use classroom time to assimilate and think via discussion, peer-interaction, formative assessment, or case method teaching[71,76-78]. In other words use classroom time more effectively and at higher levels of cognitive complexity[10,11,79]. This inverted teaching method is known as *flipped classroom*[75]. Flipped classroom can be defined as "*education in which content information on a factual level is processed outside the classroom, while elaboration and discussion of the materials is organized in a subsequent classroom meeting"*[80].

Until now, most work on flipped classrooms has shown that learning before and engaging during contact sessions improve student satisfaction[81-84] or increases performance of students on summative exams[73,74,78,85] or both. Nevertheless, Van der Vleuten and Driessen stated that "*the idea of distributing course content and focusing on student-centered learning is not new*"[86]. A commentary in the digital newsletter 'Tomorrow's Professor' supports this statement as they explained that educators have been assigning homework to student and asking questions during classroom sessions for decades[87]. The big difference with flipped classrooms is, however, that the technology can enhance the quality of students' work and provides opportunity to monitor students' learning.

Rationale

In the past decades, the affordances of technology provided an increased popularity of blended learning in higher education[28,70]. In the institution where this research was conducted, blended learning will become a significant component of the educational landscape by the year 2020. Over the past years, different approaches of technology-enhanced education were designed. The goal of this thesis was to study different blended learning approaches to determine if technology-enhanced education could stimulate student engagement and meaningful learning in courses. Attention was paid to the complete spectrum of a course (see figure 3) as experiments were focused on student preparation for in-class activities and summative exams, student engagement during in-class activities, and the retention of knowledge after a course. Additionally, teacher perception of technology-enhanced classroom innovations was explored.

Thesis outline

All studies are performed in the context of medical and biomedical education. The first three studies describe (e-)tool based experiments, while the other studies used blended learning as a didactic approach.
In more detail, Chapter 2 and 3 are focused on student preparation for summative tests, by examining the use of online formative assessments. **Chapter 2** focuses on active engagement of individual students with the course content. The aim was to investigate if the use of online formative assessments improved student learning, reflected as increased scores on the summative exam, as it is assumed that the feedback in the formative assessment would encourage students to keep studying. Students can choose to use or not use this tool, since formative assessments are often not obligatory. In **Chapter 3**, it was explored what reasons students have for using or not using online formative assessments.

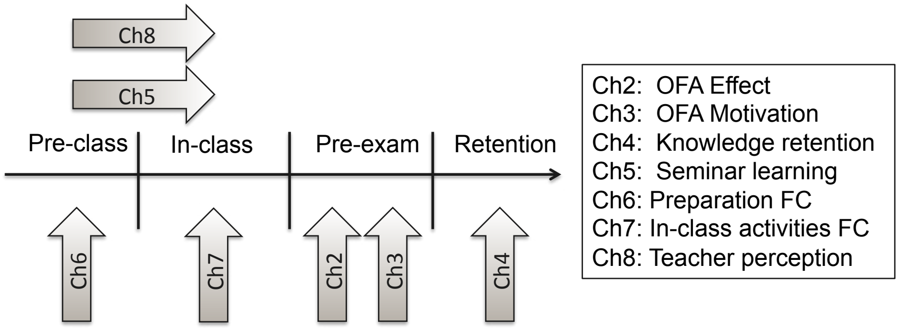

Figure 3. Focus area of each chapter

Besides providing students with feedback on current performance or judging their performance with a grade, assessments can be used as an educational method. The fact is that students reach the highest level of knowledge at the end-of-course examination. Afterwards the level of knowledge drops. In **Chapter 4** a pilot study is presented in which repetitive examination is used as a method to reduce knowledge decay over a long period of time.

In addition to experiments with blended learning tools, this thesis also looks into didactical approaches involving blended learning. **Chapter 5** is focused on a student-centered design for seminar learning. In this study it is examined whether buzz-groups and plenary discussions was able to stimulate students to prepare for and actively participate in seminar learning. As we hypothesized that peer-pressure would encourage students to engage, this study aimed to determine if peer learning in seminars would lead to improved performance on the summative exam.

Chapters 6, 7 and 8 focus on a second didactical approach for blended learning, i.e. flipped classrooms. The aim of flipped classrooms is to achieve more interactivity and a deeper understanding of the content. Therefore, students need to acquire knowledge before class in order to apply this knowledge during interactive in-class activities. Since flipped classroom is still a relatively new approach, we first explored how students prepare for in-class activities in **Chapter 6**.
The next chapter, **Chapter 7**, looks into the in-class component of flipped classrooms to establish if flipping the classroom does increase student and teacher activity.
The final study on flipped classroom is focused on teacher perception. **Chapter 8** explores the overlap of teacher expectations and teacher experiences with technology-enhanced education in order to identify unjustified hesitations and to detect real benefits.

In **Chapter 9** the outcomes of the different blended learning experiments are discussed in light of the community of inquiry framework. Since blended learning environments consist of a mixture of online and face-to-face education, more flexibility concerning the CoI domains might be possible compared to traditional or fully online education. By framing the online and face-to-face components of blended learning into the CoI framework, we aim to determine if different forms of blended learning can result in effective educational environments. The goal of these blended learning environments is to stimulate students to actively construct knowledge (Cognitive presence) and to share and discuss this information with peers (Social presence). Teachers can guide this learning process by expanding the constructed knowledge with additional facts (Teaching presence). The collaboration between students and teachers and the construction of knowledge corresponds the responsibilities of students and teachers in effective educational experiences. Note: since the framing in the community of inquiry model occurred in hindsight, this theoretical framework was not addressed in the article themselves.

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Chapter 2

Online formative assessments linked to microlectures improving academic achievement

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Abstract

Introduction: Online formative assessments (OFAs) are powerful tools to direct student learning behavior, especially when enriched with specific feedback.
Aim: In the present study, we have investigated the effect of OFAs enriched with hyperlinks to microlectures on examination scores.

Methods: OFAs, available one week preceding each midterm and the final exams, could be used voluntarily. The use of OFAs was related to scores on midterm and final exams using ANOVA, with prior academic achievement as a covariate.

Results: On average, 74% of all students used the online formative assessments (OFA+) while preparing for the summative midterm exam. OFA+ students obtained significantly higher grades compared to OFA- students, both without and with correction for previous academic achievement. Two out of three final exam scores did not significantly improve.

Conclusions: Students using online formative assessments linked to microlectures receive higher grades especially in highly aligned summative exams.

Introduction

In higher education formative assessments are a frequently used e-learning tool[1]. In contrast to summative assessments, formative assessments aim at giving students feedback on their learning and achievement with no decisive consequences for study progress[2].
Formative assessments can be used in combination with video lectures. Video recordings of lectures are increasingly used in higher education[3] and are generally appreciated by students, but recordings alone do not necessarily result in better academic achievements[4]. Students need a stimulus to watch and study them.
In this study, we designed an integrated e-learning environment which combined online formative assessments (OFA) with specific written feedback including hyperlinks to fragments of the recorded lectures (i.e. microlectures).
The aim of our study was to investigate whether the use of OFAs would increase learning, reflected in better academic achievement.

Methods

This study was conducted in a second-year course of the bachelor program of Biomedical Science Education at Utrecht University, The Netherlands.
The course is composed of three physiology-oriented parts, the Respiratory, Circulatory, and Urinary organ system, each of which is finalized with a 30 MC-items summative midterm exam. The complete course is finalized with a comprehensive final exam composed of 10 multi-disciplinary essay questions.

An OFA was accessible one week preceding each corresponding midterm exam and again one week preceding the final exam. Each OFA consisted of 30 items that were randomly picked from an item pool. The items were comparable but not similar to the midterm exam questions. Correct answers were confirmed with general feedback and more extensive feedback was given for errors. This feedback consisted of an explanation of the most obvious mistake(s) leading to a particular answer. After three attempts, general feedback including a clarification of the correct answer or a mathematical procedure was shown and students were provided with a hyperlink to the related microlecture. OFAs were neither obligatory nor rewarded with a summative score. The use of OFAs was tracked in the electronic learning environment.

Data analyses

To investigate the effect of OFAs on each midterm exam, the scores of students who completed the OFA (once or more) were compared to the scores of students who did not complete the OFA using analysis of variance (ANOVA). Student scores were used as a dependent variable; the completion of OFAs was used as a fixed factor. The ANOVAs were performed using SPSS 19.0 [IBM Corporation, New York, USA]. Previous academic achievement (i.e. average course grade of six related first-year courses) was used as a covariate in the analysis of variance (ANCOVA) to correct for individual performance differences. Final exam scores were analyzed similarly. P-values < 0.05 were considered statistically significant.

Results

Tracking data demonstrated that respectively 82, 87 and 85 students (±74%) used the online formative assessments (OFA+) while preparing for the summative midterm exam, whereas 28-33 (± 26%) did not (OFA-). For the final exam respectively 52, 42 and 48 students (on average 41%) used OFAs.

Midterm exam scores

The OFA+ students had a significantly higher mean midterm exam score (6.87±0.47) compared to OFA- students (5.77±0.70), both without and with correction for previous academic achievements ($p< 0.01$). Similarly, all three individual midterm exam scores were significantly higher for OFA+ students, compared to OFA-. After correction for previous academic achievement, only Circulatory (7.27 vs. 6.23) and Urinary (6.58 vs. 5.30) midterm exams remained significant ($p< 0.01$), while the difference for the Respiratory (6.76 vs. 5.82) midterm exam was only marginally significant ($p= 0.064$).

Final exam score

Students using OFAs when preparing for the final exam obtained higher grades for the Circulatory and Urinary exam ($p<0.05$), but not for the Respiratory exam ($p=0.139$). After correction for previous academic achievement, the difference between the two groups was no longer significant for the Urinary exam ($p=0.410$). The differences for the Circulatory exam remained significant ($p=0.026$).

Discussion

The present study demonstrates a positive effect of online formative assessments (OFAs) with specific feedback including links to microlectures on summative exam scores. The results show that the average summative multiple-choice score of students who chose to complete OFAs are higher compared to their classmates who chose not to complete OFAs, irrespective of their previous achievement. This effect might be explained by the fact that using OFAs helped students (i) identify knowledge gaps, (ii) gain insight into goals and criteria, and (iii) discover how their performance relates to these criteria[5].

Interestingly, the significant positive effect of OFAs on corrected midterm exam scores was not established for the Respiratory and Urinary final exam. The scores on the Circulatory exam remained significantly higher for OFA+ students, possibly because the Circulatory item pool was almost twice as large compared to the other pools. Taking the Circulatory OFA more than once could provide students with variable test-items, while other OFAs would show a bigger resemblance. Furthermore, some Circulatory OFA items showed overlap with final exam questions, although rephrased into open essay questions, while the Respiratory and Urinary items were less comparable to the final exam.

It can be speculated that either adaptation of study strategy[6], difference in question types[7], and/or lack of constructive alignment[8] between OFAs and particularly the Respiratory and Urinary final exams, might be the underlying cause for not improving these scores.

Limitations and strengths

One limitation to our study is that we were not able to record students' viewing of microlectures. In future studies this information could help to distinguish between rather traditional formative assessments and the assessments discussed in this manuscript. Such additional recording data could also provide a measure to determine time on task. This measure could disclose whether online formative assessment triggers increased study effort, as Cook et al. demonstrated that increased time-on-task correlates with better learning outcomes[9].

The strength of the present study lies in the fact that a solid e-learning environment was created; an environment that contains microlectures as well as formative assessments with specific feedback, including hyperlinks to these microlectures as the most important one.

Conclusion

The use of OFAs helped students to achieve better grades, especially in highly aligned summative exams.

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Chapter 3

Students' motives for using online formative assessments when preparing for summative assessments

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Abstract

Introduction: Formative assessments intend to provide feedback on student performance in order to improve and accelerate learning. Several studies have indicated that students using online formative assessments (OFAs), have better results on their exams. Aims: The present study aims to provide insight in student reasons for using or not using available OFAs.

Method: Three OFAs with feedback were available in a second year undergraduate course in physiology for biomedical sciences students (N 1⁄4 147). First, students received an open questionnaire about why they did (not) complete the first two OFAs. Based on this data, a closed questionnaire was developed and distributed among students. Exploratory factor analysis (EFA) was applied.

Results: The results indicate reasons why students do (not) use the OFAs. The EFA for using the OFAs indicated three factors, that were interpreted as collecting (1) feed up, (2) feed forward, and (3) feed back information. The main reasons for not using the OFAs were lack of time and having completed the questions before.

Conclusions: Students' reasons for using OFAs can be described in terms of collecting feed up, forward and back information and students' reasons for not using OFAs can be student-, teacher-, or mode-related.

Introduction

Self-directed learning is one of the most promising types of learning advocated in medical education to prepare medical students for continuing professional education[1-4]. Self-directed learners are able to self-appraise their work and to seek, accept and use feedback from others in order to improve their performance[5]. A tool that can be used to support the self-directed learning of students is an online formative assessment that students can voluntarily take part in while preparing for a summative exam[6-9]. Formative assessment refers to an assessment that is specifically intended to provide feedback on performance to improve and accelerate learning[10,11], as opposed to a summative assessment that summarizes the achievement of a student, often in the form of a grade[12]. The results from a formative assessment have value not in terms of completing a course, but rather providing feedback to the students as to the extent of their understanding of the course material. Thus, it can help them in planning their next learning activities[13].

Several studies have investigated the effects of online formative assessments[e.g.8,14-20], all indicating that students participating in the online formative assessment had higher scores on the subsequent summative assessment. In order to explain this effect of online formative assessments, several mechanisms have been proposed: increasing student engagement[6,21]; increasing time on task[22]; preventing procrastination[21]; and providing formative and informative feedback[6,13,19]. Interestingly however, despite the positive effects of online formative assessments, not all students use them[8,23]. This raises the issue of why students do or do not use online formative assessments and how these student reasons might be related to the different mechanisms that are proposed and so far little is known about this issue[24]. Therefore, the present study seeks to better understand the effect of online formative assessments by asking students why they chose to use or not use online formative assessments and by addressing the following research question: *what reasons do students have for using online formative assessments?*

Insight into students' reasons for using online formative assessments can (a) contribute to our understanding of the mechanisms that explain the relation between participation in online formative assessments and higher scores on summative assessments, (b) establish guidelines for the design and implementation of online formative assessments in medical education that are aligned with student reasons for using them and (c) provide suggestions for making online formative assessments more appealing to students who do not use them instantly.

Methods

This study was conducted in a second year undergraduate course in physiology for biomedical sciences students. In total, 147 students took the course, which was made up of three blocks in which the respiratory, circulatory and urinary systems were addressed. At the end of each block a summative multiple choice test was taken by the students, assessing their knowledge and skills with respect to the specific organ system. In addition, at the end of the whole course a final summative test with essay questions was taken by the students in which knowledge and skills of the three organ systems were tested.

For each of the three organ systems online formative assessments (OFAs) were available in the e-learning environment, to which all students had access. Students received feedback on their answers when they had finished the complete assessment. In case of a correct answer, the feedback confirmed / elaborated why the answer was correct. In case of a wrong answer, the feedback indicated what mistake the student most likely made. The questions of the OFA were also available beneath micro lectures of the lectures, so that students could make the test items right after watching the micro lectures. If they did so, this was not considered using the complete online formative assessment.

After the summative assessment of the second block, using tracking data from the online learning environment, we divided the students into four groups: (a) students who completed both OFA 1 (respiratory system) and OFA 2 (circulatory system) (N = 88), (b) students who completed only OFA 1 (N = 15), (c) students who completed only OFA 2 (N = 20) and (d) students who completed neither OFA 1 nor OFA 2 (N = 24). Each group received a specific email with a link to an online questionnaire with open questions about the formative assessments, so that the questions could be adapted to whether or not they completed one or two of the available OFAs (see Table 1). Respectively 43, 6, 7 and 4 students of the four groups completed the questionnaire, indicating a general response rate of 40.8%. More specifically, the response rates for the four groups of students were 49% for group (a), 40% for group (b), 35% for group (c), and 17% for group (d). This indicates a trend of students that used the OFAs being more likely to fill out the questionnaire. Two independent researchers deductively constructed a coding scheme for the short answers. Both coding schemes were compared and differences between the schemes were discussed until consensus was reached[25]. This led to the final coding scheme presented in Table 2. All student answers were coded (Cohen's kappa for reasons for completion: .76; Cohen's kappa for reasons for non-completion: .78).

Based on the final coding scheme a questionnaire was developed containing 32 questions that had to be answered on a five-point scale. In order to establish a higher response rate than was established for the online questionnaire with open questions, this questionnaire was administered on paper right after the students took the summative assessment of the third block (urinary system). So, the students could fill out the questionnaire after completing the summative assessment and hand in both at the same time. In total, 134 students returned the completed questionnaire, indeed indicating a good response rate of 91.1%. These data were analysed by inspection of the means and standard deviations and factor analyses in order to explore whether latent factors underlying students' reasons for completing and not completing the online formative assessments could be found. For the factor analyses, following the advice of Osborne and Costello[26], we used maximum likelihood estimation in combination with a direct Oblimin rotation. The number of factors was determined by inspecting the scree plot.

Completed online formative assessment	*Scale*
1. What were your main reasons for completing OFA 1/OFA 2?	Short answer
2. Completing OFA 1/OFA 2 had an added value in preparing for the summative assessment.	5 point scale (agree – disagree)
If agree: What was the added value?	Short answer
Not completed online formative assessment	
3. What were your main reasons for not completing OFA 1/OFA 2?	Short answer
General	
4a. Are you planning on completing OFA 3?	Yes / No
4b. What are your main reasons for this?	Short answer

Table 1. Questions of the first student questionnaire

Reasons for completing online formative assessment
1. Checking whether I studied sufficiently
2. Repeating and rehearsing the course material
3. Getting insight into the form and content of the summative assessment (including being prepared for the possible use of the same test items)
4. Discovering gaps in my knowledge and skills
5. Understanding what elements of the course material are important
6. Having a positive / negative experience with the previous formative/summative assessment
7. Other

Table 2. Final coding scheme for reasons for completing and not completing OFA

Reasons for not completing online formative assessment
1. Having too little time / completing the online formative assessments takes too much time
2. Having completed the test items below the micro lectures already
3. Already knowing the course material well enough
4. Finding the online formative assessment insufficiently representative of the summative assessment
5. Experiencing technical problems
6. Preferring to learn from other sources
7. Forgetting the possibility of making the online formative assessment
8. Other

Table 2. continuation

Results

Reasons for completing the online formative assessments

Most variables violated the assumption of a normal distribution, and all variables had a median of 4. Therefore, also Table 3 also presents the means and standard deviations for all variables. The fact that the median for all variables is 4, indicates that all reasons play a role for students. The first two reasons ('checking whether I studied sufficiently' and 'repeating and rehearsing the course material') proved the most important reasons for students to complete the online formative assessment, followed by 'discovering gaps in my knowledge and skills'. In addition, the least important for students were 'understanding what elements of the course material are important' and 'having a positive/negative experience with the previous formative/summative assessment'.

A factor analysis was run on all items concerning reasons for completing OFAs. The scree plot showed a hitch on the fourth factor, and therefore we chose a factor solution with three factors, which explained 51% of the total variance and the three factors having eigenvalues of respectively 4.56, 3.96 and 2.98. For interpretation of the factors, we first determined for each item the highest factor loadings (bold in table 4). Factor loadings smaller than .40 are presented in grey and cross loadings are presented in black*.

* As the data violated the assumption of normal distribution, we also ran an exploratory factor analyses for categorical data using the software package FACTOR. The results from this analyses showed an identical factor solution, that is all variables loaded highest on the same factor as in the original analyses. Therefore, we report the results of the original factor analyses.

Reasons	*to complete OFA 3 (retrospect)*	*for added value of OFA 3 (retrospect)*	*to complete OFAs before the final test (prospect)*
Checking whether I had studied sufficiently	4.3 (0.7)	4.0 (0.6)	4.1 (0.7)
Repeating and rehearsing the course material	4.3 (0.6)	4.1 (0.6)	4.4 (0.6)
Getting insight into the form and content of the summative assessment	4.0 (0.8)	3.6 (0.9)	3.6 (1.1)
Discovering gaps in my knowledge and skills	4.2 (0.8)	3.9 (0.9)	4.1 (0.8)
Understanding what elements of the course material are important	3.6 (1.1)	3.5 (0.9)	3.6 (3.6)
Having a positive/negative experience with the previous formative/summative assessment	3.5 (1.0)	-	3.7 (1.0)

Table 3. Reasons for completing OFAs and the added value in terms of means and standard deviations (N = 104 for OFA 3; N = 123 for final test)

The items with the highest factor loadings on the first factor were the three items concerning understanding what elements of the course material are important and two items concerning getting insight into the form and content of the summative assessment. Based on these high loading items we interpreted the factor as using the online formative assessments *to collect feed up information*. The online formative assessments are used to see what the format of the assessment will be and what course material will possibly be addressed. In other words, students gain information about what the goals are and what is expected of them.

Second, the items with the highest factor loadings on factor 2 were the three items concerning repeating and rehearsing the course material, the three items about discovering gaps in knowledge and skills and surprisingly one item about getting insight into the form and content of the summative assessment. Based on the first six high loading items we interpreted the factor as using the online formative assessments *to collect feed forward information*. The online formative assessments are thus also used to learn the course material (move forward) and to know what elements of the course material would need to be studied more thoroughly. The fact that also one of the items of *to collect feed up information* loaded highest on this factor, in combination with a second item cross loading on this factor, is not that strange as feed up and feed forward are not independent elements as feed forward is about how to reach the goal more closely.

	Factor		
I have completed the online formative assessment urinary system for…	1	2	3
Checking whether I studied sufficiently	.09	.46	**.48**
Repeating and rehearsing the course material	.13	**.52**	.27
Getting insight into the form and content of the summative assessment	.22	**.44**	.10
Discovering gaps in my knowledge and skills	.34	**.91**	.24
Understanding what elements of the course material are important	**.83**	.40	.12
Having a positive/negative experience with the previous formative/ summative assessment	.13	.25	**.82**
The online formative assessment urinary system had added value, because then I could…			
Check whether I had studied sufficiently	.23	.29	**.45**
Repeat and rehearse the course material	.37	**.56**	.30
Get insight into the form and content of the summative assessment	**.56**	.24	.33
Discover gaps in my knowledge and skills	.58	**.62**	.19
Understand what elements of the course material are important	**.94**	.33	.25
I will complete (at least one) online formative assessment, because…			
Then I can check whether I had studied sufficiently	.42	.33	**.53**
Then I can repeat and rehearse the course material	.18	**.56**	.40
Then I can get insight into the form and content of the summative assessment	**.66**	.41	.30
Then I can discover gaps in my knowledge and skills	.52	**.66**	.38
Then I can understand what elements of the course material are important	**.88**	.32	.26
I had a positive/negative experience with the previous formative summative assessment	.51	.37	**.83**

Table 4. Factor loadings of exploratory factor analyses on items concerning reasons for completing OFAs and the added value of OFAs with ML estimations and Oblimin rotation

Third, the items with the highest factor loadings on the factor 3 were the three items concerning checking whether a student studied sufficiently and the two items concerning previous experiences with the formative or summative assessment. Based on these high loading items this factor is interpreted as students *collecting feed back information.* First, previous experiences already indicated how a student is going and are thus used in deciding whether using the online formative assessment is needed, and second when the student completed the online formative assessment, based on the outcome the student again checks where (s) he stands in relation to the goal. In total, 8 out of the 17 items cross loaded on a second factor, indicating that these items were not strong in distinguishing the different factors.

Reasons for not completing the online formative assessments
Table 5 provides the medians of the different reasons for not completing the online formative assessments that were found in the qualitative measurement. From the table it can be seen that in general most reasons have reasonably low medians, indicating that not all reasons seem to play a role for students. Given the small *N* for the items of the second column of table 5, only the items from the first column were used in the factor analyses. This yielded a factor solution with only one factor, indicating that no clear underlying factor structure could be found for these items.

Reasons	*not to complete the OFA Kidney (retrospect)*	*not to complete OFAs preparing for the final test (prospect)*
Having too little time / making the OFA takes too much time	**4**	2
Having completed the test items below the micro lectures already	**4**	2
Already knowing the course material well enough	2	2
Finding the OFA insufficiently representative of the summative assessment	2	**3**
Experiencing technical problems	1	1
Preferring to learn from other sources	**3**	2

Table 5. Medians for reasons for not completing OFAs (N = 29; N = 9)

Discussion
This paper explored student reasons for using online formative assessments when preparing for a summative assessment in a physiology course for biomedical sciences. Based on qualitative data gathered through open questions, a category system was developed that described the different motives students gave for making use of the online formative assessments, or not. In total six different reasons for making use of the online formative assessments were found, and seven reasons for not using them. Factor analyses on these seven reasons did not result in a clear factor structure for the function of not completing the online formative assessments. For the six reasons for completing the online formative assessments, three factors were found. Based on the work of Sadler[12] and Hattie and Timperley[27], the factors were interpreted as describing the underlying motives of collecting

three types of information: (a) feed up, (b) feed back and (c) feed forward. Sadler[12] argued that in order for students to use feedback for self-regulation in their learning process, they should seek information about (a) what the goals, standards and criteria are, (b) how their current performance relates to these criteria and (c) what they can do to close the gap between their current performance and the standards. Hattie and Timperley[27] named these three elements feed up, feed back and feed forward. Our findings thus indicate the feedback function being an important explaining mechanism for the positive effects of online formative assessments on summative exam scores, rather than just increasing time on task[22] and preventing procrastination[21].

When we compare the three functions of online formative assessments to other studies investigating online formative assessments, several consistencies appear. These studies explored the student experience of online formative assessment, but did not aim principally to gain insight into the specific functions. For instance, in line with the notion of feed up, Sly[23] argued that an important function of formative assessments is that it gives students an idea about what is expected of them in the summative assessment in terms of both content and form. Also, Henly[7], based on anecdotal evidence from informal student feedback, described two ways students could use the online formative assessment. In the beginning, they used it after they studied the course material to check whether they understood the course material properly (i.e. feed back). Later in the course they used the online formative assessment to guide their learning, i.e. before studying the course material (i.e. feed forward). Unfortunately, the design of our study does not allow us to draw such sequential conclusions as to how student use of online formative assessments changed during the course. Still, in line with Henly's[7] finding, Walker, Topping and Rodrigues[28] also found that students used e-assessments to identify areas of strengths and weaknesses in order to study further the course material (i.e. feed forward). Thus, the three factors we found can explain the preliminary research findings of other studies as well, suggesting that our findings are not specific to our sample only.

Concerning the findings of the present study about reasons for non-completion of the online formative assessments, it is important to bear in mind that some of the students indicated that they had already used the formative questions in another part of the electronic learning environment. In other words, these students did use the formative questions but not in the form of an online formative assessment. Therefore, these findings might not be interpreted as if the students were uninterested in practicing questions at all. That being said, our findings are now discussed in relation to findings on non-attendance in medical education, as this might give some indication of the extent to which our findings are specific to the use of online formative assessments or possibly can be generalized to students not being willing to participate in learning activities in general. For instance, Mattick, Crocker and Bligh[29] found that students reported both student-related and teaching-related factors for not attending lectures. In the present study 'Finding the online formative assessment insufficiently representative of the summative assessment', could be considered a teaching-related factor and the other reasons (with the exception of technical problems) can be considered to be student-related, as these mainly describe students' learning preferences. This is also in line with the findings of Billings-Gagliardi and Mazor[30], who found that student decisions to attend lectures were among others based on personal learning preferences and learning needs at a particular time. Lastly, 'Experiencing technical problems' is neither a teaching-related nor student-related factor and is therefore interpreted as a mode-related factor. We thus conclude that students' reasons for not using online formative assessments can be student-related and/or teaching-related, but can also be mode-related, which might be specific for online formative assessments.

Implications

In general, the findings of this study indicate that students used the online formative assessments for acquiring information with respect to understanding what is expected of them on the summative assessment, both in terms of form and content (feed up), and to what extent they have already acquired the course material (feed back), and to what extent they need to study further topics (feed back). In other words, they confirm the notion of Gibbs and Simpson[31] that not only *summative,* but also *formative* assessment strongly drives learning. For the use of online formative assessments in practice, this indicates the importance of *constructive alignment* of formative and summative assessments as students use information from the formative assessment to self-regulate their learning activities in preparing the summative assessment, i.e. "we have first to be clear about what we want students to learn, and then teach and assess accordingly in an aligned system of instruction"[32(p.8)]. It is thus important that formative assessments clearly reflect the learning objectives and therefore the content, level and types of questions of the summative assessment, in order to provide students with the opportunity to use properly the information that is acquired to prepare for the summative assessment.

With respect to the reasons for not completing the online formative assessments, we think some reasons might be overcome and some might not. As addressed above, the formative assessment not being representative of the summative assessment is a reason that might be overcome with strong constructive alignment. Also, the aim can be to avoid technical problems when using the online formative assessments. However, the student-related reasons indicate that online formative assessment might not suit the preferred learning activities of all students. Therefore, it is important to design rich (online) learning environments so that students can study course material and prepare for assessments in a way that matches their preference.

Limitations

The design of this study has some drawbacks that should be kept in mind when drawing conclusions from these findings, based on which suggestions for future studies are provided. First, the present study was conducted during one course only and study strategies can differ considerably between courses[e.g. 33]. Therefore, these reasons should be viewed as course-specific. Also, concerning inter-generalizability, future research is needed to validate the three functions that were found in order to see whether these motives also play a role in other courses with online formative assessments specifically, or other non-compulsory study activities in general.

Second, in the present study, only a small number of students had not completed the online formative assessments, so we had only minimal data about them. In future studies it would be interesting to collect more data from these kinds of students so that for the reasons for not completing the online formative assessments general motives or functions underlying the separate items could also be investigated. Also, in the present study, students could use the questions from the online formative assessments in combination with viewing the micro lectures, which makes the group of students not completing the online formative assessments a rather heterogeneous group. For research purposes it would have been better if the online formative assessments were the only way to access the test questions. Lastly, future studies might investigate whether different groups of students can be described based on their scores on the different motives using for instance cluster analyses. This would provide insight into how the three functions are related within students.

Conclusion

The results of this paper revealed different student reasons for completing or not completing online formative assessments. More specifically, despite the fact that no clear factor structure was found for reasons for not completing, it is concluded that these reasons can be student-related, teaching-related and/or mode-related. As regards the reasons for completing three underlying types of information we found that by using the online formative assessments, students acquire: (a) feed up (what is expected of me in the summative assessment in terms of content and form?), (b) feed back (to what extent have I already mastered the course material?) and (c) feed forward (do I need to study more and if so, what do I need to study?). These findings can be related to findings of both Sadler[12] and Hattie and Timperley[27] and confirm preliminary indications about the use of online formative assessments[7,23,28] and findings about motives for lecture attendance[29,30]. The results of the present study yield important theoretical insights into why students do or do not use online formative assessment and indicate that, for practice, attention should be paid to constructive alignment of instruction, formative assessments and summative assessments[31,32].

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Chapter 4

Does repetitive assessment improve knowledge retention? A pilot study

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Not published

Abstract

Introduction: It is generally accepted that students reach their highest level of knowledge at the moment of summative end-of-course examination. After this moment the level of knowledge often quickly drops.

AIM: This study investigates whether repetitive examination (without additional study) can reduce knowledge decay over time.

Method: All 354 first year medical students were invited to participate in this study of which 65 volunteered. Students were randomly assigned to an intervention group or control group.
In the first six weeks after the end-of-course exam, the intervention group (N=34) was given three scheduled examinations comparable to the end-of-course exam. Instructions indicated additional study was not permitted. The control group (N= 31 students) did not take these interventional exams. Six months later all students were invited to take a retention test similar to the end-of-course exam.

Results: Intervention and control group students scored 73,3% and 74,4% correct answers on the MCQ-items on the initial end-of-course exam respectively. After seven months, students in the intervention group lost, on average, 9% of their knowledge, while control group students lost 13.4%, but this knowledge decay among control group students was not significantly higher than among students taking the intervention tests (p=0.201).

Conclusion: Actively processing study material via repetitive assessment without additional study effort may help students retain more knowledge, but the findings were inconclusive, possibly because of a low experimental power. Another investigation with better control of conditions and less experimental mortality is recommended.

Introduction

In medical education the importance of basic science knowledge, in relating clinical phenomena to pathophysiology has been widely acknowledged[1-5]. Still, the depth of biomedical science knowledge required for the clinical training phase[6] and for clinical practice is a matter of debate[7,8]. One aim of medical education is to optimize the retention and application of the acquired knowledge and skills[9]

Although it is assumed that students will remember some of the knowledge and skills that are taught[10], it is generally accepted that the highest level of knowledge is reached when students take a summative end-of-course exam[11,12]. Moreover, medical students have repeatedly shown to be excellent test takers[13]. Still the level of knowledge reduces dramatically afterwards. According to Custers and ten Cate, approximately one third of the acquired knowledge will be forgotten within the first year if not used, revisited or relearned[14]. After one year, forgetting continues to nearly 50-60 percent[10,14,15]. In other words, knowledge retention decreases as time passes[16]. Many clinical educators are concerned about the (biomedical) knowledge of medical students, generally acquired during the first years of medical education, once they enter the clinical phase of medical education[11,17].

Different strategies to diminish decay of knowledge have been studied and their results indicate that short-term retention could be improved by adapting the teaching formats. For example the introduction of interactive learning with the use of an audience response system improves knowledge retention, compared to a standard lecture format[18]. Similar results were found for practicing with virtual patients[19] and online tutorials[20]. Long-term retention however did not increase in these studies. To improve long-term retention spaced testing or reviewing after as little as 1 week has been suggested[20].
Rohrer and Taylor, and Turner et al. have tested this hypothesis of spaced practice. Their studies have shown that separated practice sessions[21] or unannounced testing by telephone[22] improved the retention of knowledge for 4 weeks and 2 months respectively, although these intervals are still relatively short.
The current study investigates whether scheduled short interval examinations can improve the retention of knowledge over a period of 7 months. It is hypothesized that students who repeatedly and intensively use their acquired knowledge will sustain a higher level of knowledge compared to peers.

Methods

The intervention

The intervention involved re-examination of acquired knowledge at set intervals: three days, one week and six weeks after the end-of-course exam. Seven months (33 weeks) after the initial exam all participants were invited to take the retention-test to determine the percentage of retained knowledge. Students were instructed not to study for any of these tests, since additional study effort could obviously improve scores. The obtained scores on the tests were only to be used for research purposes.

Interventional exams 1 and 2 were solely composed of 56 multiple-choice questions (MCQ). Interventional exam 3 and the retention-test were identical to the end-of-course exam, although the arrangement of both questions and answer options were shuffled. These exams each consisted of the same 46 MCQ and 7 open ended essay questions. All tests were pencil and paper exams taken under standard-test conditions. The intervention and retention exams covered all topics taught in the first year medical course ‘Nerves, brain and movement-1 (‘ZHB-1’).

One researcher, RB, scored all intervention and retention test items according to the guidelines and model answers provided by the examiner of the course. Subsequently, percentages of correct MCQ answers were calculated for each exam. Knowledge decay was calculated by subtracting retention test scores from scores obtained with the original end-of-course exam.

Participants

This study was performed in first year medical students in the 2012-2013 academic cohort at Utrecht University, The Netherlands. After invitation by the course director and the research team students were recruited via e-mail. From the 354 students that were invited, 65 responded as volunteers. All volunteers completed the end-of-course examination and were randomly assigned to the intervention group (N= 34) or the control group (N=31). Selection was done with the use of a random table. The flow chart of this study and the number of participants is shown in figure 1.

In total 21 students were excluded from statistical analyses; 11 intervention group students did not complete the intervention. Five control group students were excluded because they did not take the retention test and five (three intervention and two control group) students were excluded since they failed their end-of-course exam. Failing the exam is an exclusion criterion, because obligatory re-examination requires students to study the course material, and additional study effort is a confounding factor in this study.

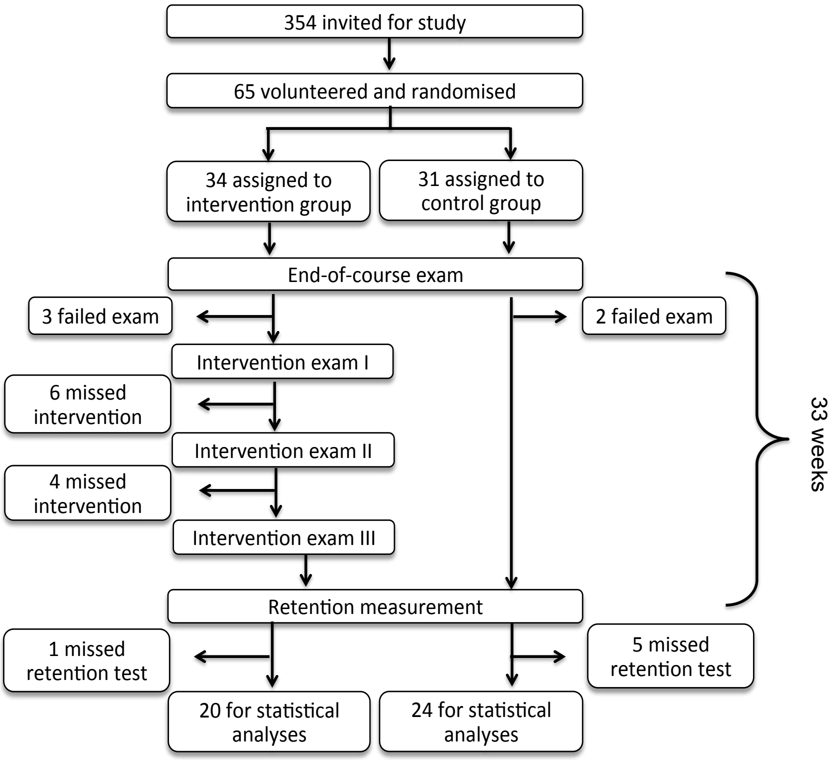

Figure 1. flow chart of voluntarily participating students.

Ethics

The ethical review board of the Netherlands Association for Medical Education approved this study (NVMO-ERB; dossier number 200). All participants signed the informed consent form with information about the goals and data handling methods of this study. After the retention test, all participants, both intervention and control group students, were reimbursed with a gift certificate of 15 Euro.

Statistical analyses

To determine differences in percentages of correct answers between students in the control group and students taking the intervention tests, independent samples T-tests were performed. T-tests were done for the scores on the end-of-course exam (to confirm equal randomization), the retention-test and the percentage of knowledge decay. Analysis was performed using SPSS 20.0 [IBM Corporation, New York, USA]. p-values <.05 were considered statistically significant.

Results

In total 65/354 (18%) students accepted the invitation to participate in this study. Data from 20/34 (59%) students assigned to the intervention group and 24/31 (77%) assigned to the control group were available for statistical analyses.

The average percentage of correct answers on the initial exam was 73.3 ± 8.9% for intervention group students (Table 1). Control group students scored on average 74.4 ± 11.9% correct. An independent-sample T-test indicated that the difference between these scores was not statistically significant (T(42)= -0.357, p=0.723). The complete cohort answered on average 68.8 ± 11.9% of the MC questions correctly.

	Control group N (%)	*Intervention group N (%)*	*Complete cohort N (%)*
Original exam	34 (74.4%)	34 (73.3%)	32 (68.8%)
Retention test	28 (61.0%)	30 (64.3%)	/

Table 1. Number of correct answers and percentage of correct scores per group.

Scores on the retention-test were 64.3± 11.6% correct for intervention group students, control group students answered on average 61.0± 9.9% correct (T(42)= 0.999, p=0.324).
As shown in Figure 2, exam scores of students in the intervention groups appear to be less decreased (9.0%) compared to control group students (13.4%), however statistical significance could not be found (T(42)= -1.300, p=0.201).

Discussion

One suggested solution to reduce the decay of knowledge over time is a repeated stimulus to actively process acquired knowledge. Repetitive examination is an example of such a stimulus and its effect on knowledge retention was investigated in this study. The observed difference in knowledge decay (9.0% versus 13.4%) may lead to believe that actively processing study material via repetitive examination without additional study effort could improves knowledge retention. Unfortunately, the current findings are inconclusive.

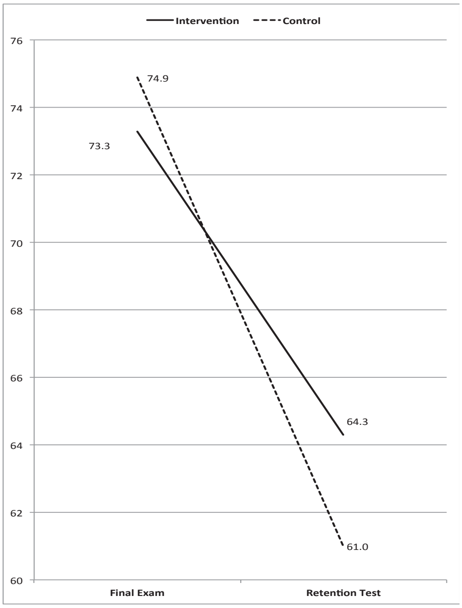

Figure 2. The decay of knowledge per group. The continuous line represents knowledge decay of intervention group students. The dotted line represents knowledge decay of control group students.

The limitations to this study might explain why we were not able to find the expected effect. First of all, the study was conducted with a small number of participants and we observed a large experimental mortality, especially in the intervention group. This attrition bias is a frequently found cause for type-II errors in research. Increasing the sample size will make differences more pronounced[23]. Secondly, participating students were all volunteers and volunteers tend to be the more cleaver students[10,14]. In the current study, participating students scored on average 73-74% correct on the initial exam, whereas the complete cohort achieved an average score of 69% correct. This selection bias became even more evident, since students failing their end-of-course exam were excluded from statistical analyses, because re-examination requires additional study effort, which is an exclusion criterion. However volunteers were randomly assigned to either the intervention or control group. As a consequence, selection bias in the intervention group is as large as the selection bias in the control group, and we therefore do not expect differences between these groups.

Thirdly, to our opinion, the overall knowledge decay for both the intervention and control group was relatively low. Students lost on average 9-13% of their knowledge even though a reduction of up to one third might be expected in the first year[14]. It is questionable whether students' level of knowledge would have dropped to these numbers after one year. Additionally, our choice to intervene after three days, one week and one month might also be debated. We deliberately chose short-term intervals since the decay of knowledge is most pronounced directly after the summative examination, as suggested by Ebbinghaus[11,16]. However, the most effective distribution of interventions is not clear.

Finally, the retest effect might have influenced our study results, because we chose to examine the retention of knowledge with a test that resembled the end-of-course exam as well as the third intervention test. According to Turner and coworkers, this retest effect is caused by familiarity with the test content and format and might lead to improved performance[22]. Although we intentionally shuffled the arrangement of both questions and answer options, the retest effect is likely to be largest in the intervention group and could explain the smaller decay in knowledge over time.

Proposal for a new study

The effect of repetitive assessment without additional study on the retention of knowledge could not be fully investigated in this pilot study possibly due to a low experimental power. We would like to propose a new study to further investigate the effect of repeated examination on long-term knowledge retention.

Study design

To determine long-term knowledge retention an extended retention interval of at least one year between the third intervention test and the retention exam is advised. However, a (second) retention test by the time the first year students enter the clinical training phase, approximately three years later, could provide even more valuable information with regard to educational methods of the preclinical phase.

Intervention

The end-of-course exam and retention exam should consist of different test items, but the content of these questions should be identical. With these comparable tests researchers will be able to determine knowledge retention, but will reduce bias in study results. In addition, exams might be composed of both MCQ and open-ended questions. Comparing the retention scores on both question types might add new evidence to the ongoing discussion whether facts[10] or concepts[22,24] are better recalled over time.

Participants

Last but not least, the sample size of both the intervention and the control group should be increased. Power analysis, based on the calculated knowledge decay in this study, has indicated that groups needed to be fifteen times as large in order to find significant differences. This is most likely due to the large standard deviations that were observed. In total approximately 340 students should be included in order to find statistically significant differences. In addition, special effort must be made to reduce experimental mortality. Therefore, it is recommended to schedule the (voluntary) intervention and retention tests in such a way that student can easily take them, for instance between two mandatory lectures. On the other hand, response rates might increase when incentives are prepaid. Petrolia and Bhattacharjee[25] and McGonagle et al.[26] both provide experimental evidence supporting this incentive effect.
Taking both attrition factors into account, leads us to believe that comparison of two subsequent cohorts might be the best way to go. In that case, one cohort should be treated as the experimental control group, only taking the end-of-course and retention exams, whereas the second cohort should be treated as the intervention group.

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Chapter 5

Peer-instructed seminar attendance is associated with improved preparation, deeper learning and higher exam scores: a survey study

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BMC Medical Education, 2016

Abstract

Introduction Active engagement in education improves learning outcomes. To enhance active participation in seminars, a student-centered course design was implemented and evaluated in terms of self-reported preparation, student motivation and exam scores.
We hypothesized that small group learning with intensive peer interaction, using buzz-groups followed by plenary discussion, would motivate students to prepare seminar assignments at home and to actively engage in the seminars. Active engagement involved discussion of the preparatory assignments until consensus was reached.

Methods In total 7 seminars were scheduled in a 10-week physiology course of an undergraduate Biomedical Sciences program. After each seminar, students were asked to fill out their perceptions of preparation and quality of the seminar (deepening of knowledge and confidence in answers) on a five-point scale using electronic questionnaires. Student motives were first collected using open questions. In the final questionnaire students were asked to indicate on a five-point scale how each motive was perceived. Students overall explanations why they had learned from seminars were collected via open questions in the final questionnaire. One hundred and twenty-four students of the cohort from 2012-2013 (82.6%) voluntarily participated. Students' motives to prepare and attend seminars were analyzed by inspection of descriptive statistics. Linear regression analysis was conducted to relate student preparation to the quality of seminars, seminar attendance to exam scores, and exam scores to the quality of seminars. Answers to open questions were deductively clustered.

Results Studying the material, training for exams and comparing answers with peers motivated students to prepare the seminars. Students were motivated to participate actively because they wanted to keep track of correct answers themselves, to better understand the content and to be able to present their findings in plenary discussions.
Perceived preparation of peers was positively associated with the perceived quality of seminars. Also, seminar attendance was positively associated with exam scores. Students' overall explanations suggest that discussing with peers and applying knowledge in pathophysiology cases underlies this association.

Conclusion

Discussion with well-prepared peers during seminars improves student perceptions of deeper learning and peer-instructed seminar attendance was associated with higher exam scores.

5

Introduction

Active participation in educational activities is essential for learning[1-3] since active participation improves students' level of understanding, the ability to process material, and the retention of knowledge[4-6]. As a consequence exam scores of students participating in active learning environments are often higher than those of students attending traditional lectures[6]. However, not all students engage in learning activities and are, therefore, usually identified as passive recipients of information[7]. Lack of preparation, most likely caused by low levels of motivation is a probable cause for students not to participate actively in learning activities[8]. As a consequence, these students are assumed to learn less than students who participate actively in learning activities.

The importance of active learning has also been acknowledged in (bio-) medical education[3]. Medical education settings have, therefore, changed the traditionally passive faculty-centered environments into active student-centered learning environments[9,10]. Next to small group learning or problem-based learning, seminar learning is an important form of an activating student-centered learning environment[11,12].

During seminar learning, groups of (25–30) students discuss questions and issues under supervision of a content expert[13]. An important aim of seminar learning is to enhance peer-instruction, which involves students to explain topics to one another using their own words. These explanations should then be very specific and concrete[14,15]. Peer-instruction is known to promote long-term memory[16,17] and provides students with insight into their level of understanding and their performance. In addition, teachers can identify student's needs, determine how students assimilate information and indicate future learning directions[7].

Spruijt and co-workers have identified three factors for successful seminar learning[18,19]. First, the preparation material as well as the seminar assignments should be manageable and of good quality according to both students and teachers. Second, seminars should be well structured and clearly connected to other educational methods; a characteristic also known as constructive alignment[20] since students are likely to adopt a surface approach to learning when constructive alignment is lacking[21]. The third requirement for efficient seminar learning is a course schedule that allows sufficient time to prepare seminar assignments. Students considered preparation to have a major impact on their learning, because it enhanced the value of participating in the seminar[18].

Interestingly some discrepancies between educational theory and practice have been described[22,23]. For example, Jaarsma and co-workers observed that interactions within seminars were predominantly between the teacher and the students while few student–student interactions occurred meaning less opportunity for peer-instruction[24].

Similar to the descriptions of Jaarsma et al., seminars in the current study were aimed at deep learning by peer-discussion. Even though these seminars were based on pre-assigned seminar assignments instead of literature readings[13], teachers observed that only a limited number of students fully prepared the seminar assignments and few student-student interactions occurred.

In this study we investigated if a student-centered design stimulated students to prepare and participate actively in seminar learning, leading to improved academic outcome. We made the seminar groups seem smaller[25] by introducing buzz groups[26] followed by a plenary peer-driven discussion. We hypothesized that the combination of smaller groups and a highly aligned educational design would positively influence study behavior, such that students would prepare the assignments, more student-student interactions would occur, and learning outcome would improve. In addition, we aimed to unravel the underlying mechanism, by investigating what stimulated and reduced students' motivation to prepare for and participate actively in seminars.

Methods

Educational setting

This survey study was conducted in 2013 in a second-year undergraduate 10-week physiology course, named 'Organ Systems', of the undergraduate program Biomedical Sciences at Utrecht University in the Netherlands. The course load was 20 hours per week (i.e. 50 percent of student time) and is composed of four parts. First, three physiology-oriented parts focus sequentially on the Respiratory, Circulatory, and Urinary organ systems, which were each finalized with a multiple-choice (MCQ) exam, followed by an integrative part about the pathophysiology of heart failure. All parts took two weeks, except for the Urinary system, which took three weeks. The final week of the course was spent on self-directed preparation for the final exam, consisting of open-ended essay questions.

In the three physiology-oriented parts, each week, six of the twenty hours were spent as contact sessions between students and teachers, including one seminar per week. The seminars were not obligatory, but attendance was strongly encouraged by the coordinator of the course. Each seminar was scheduled for two hours on the day after a lecture on the same topic. The remaining 14 hours were available for preparation for the lectures, seminars, summative MCQ and essay exams.

Seminars

To enhance student preparation and active participation, the format of seminars was redesigned. First, students could individually prepare the six seminar assignments as homework. The answers on assignments were than discussed in buzz groups of ideally five students[27] in the first part of the seminar. Students were thereby encouraged to compare and discuss their answers until consensus was reached. During the second part of the seminar, each buzz group was assigned to present their answer to one of the six seminar assignments to the whole group of 30 students. Their answer was reviewed and supplemented by other buzz groups in a plenary discussion. The seminar teacher moderated the classroom discussions and kept track of the answers to ensure they were correct and complete.
Finally, students could recapitulate their seminar answers supplemented with peer comments by writing a summary of their presented assignment on a so-called *wiki*, which was part of the online learning environment. Every seminar group had its own wiki, so in total there were five wikis. Together, the answers of all seminar assignments represent a clear overview of the main topics taught during the course.

Participants

Yearly, 150 students enroll in the physiology course Organ systems. To stimulate peer-instruction in seminars, the 150 students were divided into five groups of 30 students and every group was further divided into six buzz groups of five students[25,27]. The composition of these buzz groups was deliberately maintained over the duration of the course, to stimulate students to improve their performance and participation in the seminars.
One hundred and twenty-four students of the cohort from 2012-2013 (82.6%) participated in this study by signing an informed consent form providing them with information about the goals and data handling methods of this study and all seminar groups were represented. Participation was voluntarily and students who filled out 6 or 7 questionnaires were given a €10 gift certificate as compensation for their time.

A content expert guided each seminar. In total three biologists taught the respiratory and cardiovascular seminars and three veterinarians were renal experts. This study was approved by the Ethical Review Board of the Netherlands Association for Medical Education (NVMO).

Alignment

Seminar assignments were redesigned and constructively aligned to the cognitive learning and thinking activities of the summative essay exam, which reflect the learning goals of the course, using a coding scheme described by Overman et al.[28]. Learning activities stimulating students to *relate, structure, analyze, apply* and *concretize* were aimed for. Two educational researchers inspected the overlap between exam items, seminar assignments and learning goals. Teachers approved the overlap.

Procedure

To determine students' self-reported study behavior, participants were invited to fill out an online questionnaire consisting of Likert-type items and open questions after every seminar. For the final questionnaire, based on answers given in all previous questionnaires, the open questions were transformed into statements to be rated on five-point scales. After linking the questionnaire data to students' exam scores and previous test scores, data were anonymized for further analyses. On average 102 students (82.3%) filled out each online questionnaire. Twenty-six students filled out all seven questionnaires.

Data collection

First, with respect to student preparation, after each of the seven seminars students were asked if they were able to complete the assignments individually (yes or no) and how many hours they spent on preparing the seminar assignments (open). Next, they were asked to indicate on a five-point scale how well they perceived their peers to have prepared the seminar assignments (the endpoints of this scale were anchored as 1 = very poorly and 5 = very good). Additionally, students were asked six times to indicate what increased and/or decreased their motivation to prepare the seminar assignments. In the final questionnaire, students were asked to indicate on five-point scales how each motivating and demotivating item was perceived (the endpoints of these scales were anchored as 1= little contribution/ little reduction and 5 = large contribution/large reduction).

Second, with respect to the actual seminars, student attendance was measured by headcount. Also, student motivations and demotivations to participate actively in seminars were collected similar to motivations for preparation (using anchored scales with 1= little contribution/ little reduction and 5 = large contribution/large reduction). Concerning demotivation, the answers provided by the subgroup of students who chose not to attend the last three seminars, were analyzed separately as well. In addition, student perceptions of the quality of the seminars were measured on a five-point scale in the online questionnaires with the following two questions: '*To what extent did the seminar deepen your knowledge of topics discussed during the lecture?*' and '*To what extent are you confident that you and your peers found the correct answer?*' Both scales were anchored with 1=very little and 5= very much.

Third, the summative exam scores were collected of participating students and as a proxy measure for previous academic achievement, students' course grades of six previous but related courses in their first year of Biomedical Science education were collected and averaged.

Student and teacher perceptions of the quality of the seminars

Students were asked to describe how much they had learned from the seminars in general and to elaborate on their answer in the final online questionnaire. This question was answered by 91 students (73.4%). Some students provided more than one explanation. Students' explanations were deductively clustered after carefully reading all responses to this question. An education researcher checked if clustering was logical and if themes were comprehensive.

In addition to student evaluation, all six teachers were asked to fill out a short open-ended questionnaire to determine their experience of the new seminar format and their perceptions of students' preparation and participation. The questionnaire consisted of seven open-ended questions. Besides two general questions, teachers were asked how they experienced teaching the seminars and to describe which changes they had observed in student behavior and which expected behavior was missing. In addition, teachers were asked to determine advantages and disadvantages by comparing the new seminar format to the traditional seminars guided in previous cohorts. The response rate to this questionnaire was 100%. Teacher responses to the questionnaire were thoroughly discussed in the research team. In the discussion main advantages and disadvantages were identified and clustered.

Statistical analyses

Descriptives

Self-reported preparation time and the five-point scale items (perceived preparation of peers, deepening of knowledge and confidence in correct answers) were analyzed by inspection of frequencies and descriptive statistics using SPSS 20.0 [IBM Corporation, New York, USA]. Motives to prepare and motives to participate actively were analyzed similarly. We determined the percentage of students that were explicitly positive, in other words who responded with a 4 or 5. When this proportion was larger than 50% we interpreted the motives to be largely shared by students.

Four variables (i.e. preparation time, perceived preparation of peers, confidence in answers and deepening of knowledge) were measured in all seven questionnaires. In order to use this variable in the regression analyses, we had to transform these seven measurements into one score. Therefore, we calculated to average perception of each variable. However, the measurements of the fifth seminar were excluded, because the low participation rate induced teachers to use a different teaching strategy. Instead of the procedure described above, teachers were directly discussing the seminar assignments with all attendees.

Regression analyses

First, the association of seminar preparation with the perceived quality of the seminar session was investigated. Therefore, we used as dependent variables perceived ‘deepening of knowledge’ and ‘confident in answers’. Independent variables were self-reported preparation time and the perceived preparation of peers.

Second, the association of seminar attendance with improved performance was investigated. The summative exam score was the dependent variable and number of seminars attended was the independent variable. Additionally, in this model we controlled for previous academic achievement, as we would expect the students who are generally more motivated and more intelligent would attend more seminars and, therefore, score better on the exam in any situation.

Lastly, the association of students’ performance on the summative exam with the perceived quality of the seminar sessions was investigated. Therefore, exam scores were used as the dependent variable, and student perceptions of ‘deepening of knowledge’ and ‘confidence in answers’ were used as independent variables. Again, previous academic achievement was controlled for. P-values < 0.05 were considered statistically significant.

Results

Alignment

As illustrated in Figure 1, the 28 exam items (shown in black) covered all cognitive learning activities that were aimed for in the learning goals of the course. The overlap between the 140 seminar assignments (shown in grey) and the exam items was satisfactory to teachers.

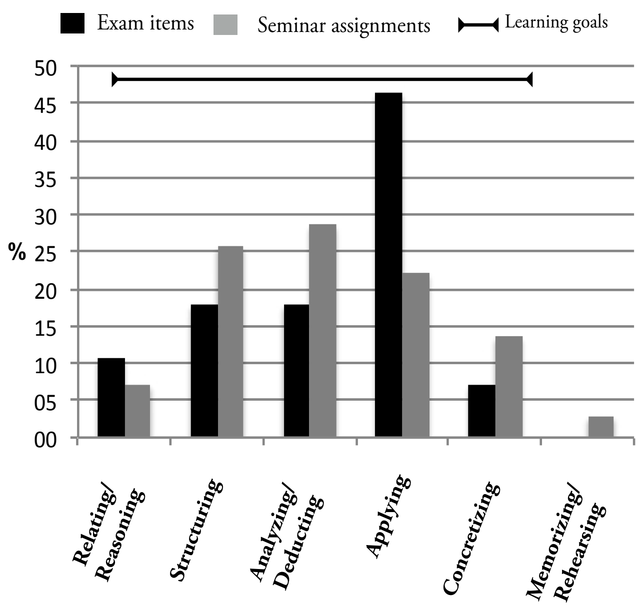

Figure 1. Alignment of exam items and seminar assignments to learning goals.
All exam items (black) and most seminar assignments (grey) overlap with the intended learning goals indicated with '⟼'. Y-axis represents percentages of items. Categories, in descending order of cognitive complexity, are indicated on the x-axis.

Preparation for seminars

As is shown in Table 1, self-reported preparation time was comparable for all sessions, on average students spent 1.59 to 1.91 hours per seminar to prepare the assignments. Within this preparation time, 61-62% of students completed the assignments of every first session of a new topic (session 1, 3 and 5). In contrast, 35-44% completed this task for the final session of each topic (session 2, 4 and 7).

More than 50% of the students perceived the preparation of peers to be (very) good for most seminars. In the first session 47% were perceive to be prepared good, whereas only 31% was perceived prepared well for the fifth session. Students were most satisfied with the preparation of their peers during the second session, as 79% of the students scored 4 or 5.

Comparison of self-reported preparation and perceived preparation of peers suggests that students were more satisfied with the preparation of their peers when a smaller number of students was able to complete the assignments at home (like sessions 2, 4 and 7). Conversely, students were less satisfied with the preparation of their peers, when a larger portion of students was able to complete the assignments on their own, as is the case in sessions 1, 3 and 5.

Session	*Seminar*	*Self-reported participation (N (% total))*	*Completion (N)(% partic)*	*Min (h)*	*Max (h)*	*Mean (SD) (h)*	*Perceived preparation peers*	
							Mean (SD)	*≥ 4 (%)*
1	Resp 1	103 (83)	64 (62)	0	5	1.68 (1.00)	3.37 (1.02)	46.6
2	Resp 2	98 (79)	37 (38)	0	7	1.91 (1.09)	4.15 (0.88)	79.1
3	Circ 1	88 (68)	54 (61)	0	5	1.74 (0.99)	3.60 (0.92)	59.1
4	Circ 2	82 (66)	29 (35)	0	5	1.59 (1.07)	3.88 (0.90)	70.4
5	Uri 1	36 (29)	22 (61)	0	7	1.60 (1.43)	2.83 (1.13)	30.5
6	Uri 2	67 (54)	36 (54)	0	5	1.63 (0.95)	3.51 (0.89)	52.2
7	Uri 3	93 (75)	38 (44)	0	5	1.63 (1.35)	3.44 (1.08)	50.6

Table 1. Self-reported and perceived preparation
Self-reported participation and the completion of homework assignments was questioned using the multiple-choice options "Yes or No". Preparation time was asked via a free text question. The perceived preparation of peers was surveyed using an anchored scale ranging from 1 (very poorly) to 5 (very good). ≥ 4 (%) illustrates the percentage of students rating the Likert-items with a 4 or 5.

Table 2 shows that, with 78% of the students scoring a 4 or 5, main reason for preparing the seminar assignments was to study the material before the upcoming multiple-choice exam. Related to that, 73% of the students claim to realize that seminar assignments would be a useful training for the end-of-course exams. In addition, 53% of the students wanted to know whether they could complete the

assignments on their own before discussing their answers with peers and 57% wanted to compare their own answers to answers given by their peers.
In general it seems that students' motivation to prepare for seminars relate to their autonomy.
The majority of students did score a 4 or 5 to one of the self-reported argument describing students reduced motivation. The most demotivating argument, to which 46% of the students agreed, was that students preferred to spend time on (learning) activities other than preparing the assignments. In addition, 33% of the students indicated that seminar assignments were too difficult to prepare individually, whereas 29% of the students claimed that seminar assignments would be repeated twice during the seminar.

Active participation during seminars

Headcount indicated that attendance of seminars decreased over time. Seventy-nine percent of the students attended both seminars concerning the Respiratory system, 71% attended both seminars involving the Cardiovascular system, whereas 22% (27 students) attended all three seminars involving the Urinary system. Likewise, the number of students attending neither of the seminars of a topic increased over time from 3% to 24%.
The total number of answers to assignments shared via the wiki's also reduced over time. On average 90% of the answers were shared on wiki's concerning the Respiratory system. Wiki's regarding the Circulatory system contained 55% of the answers, whereas only 37% of the answers about the Urinary system were shared. However, the contribution to wiki's varied largely between seminar groups. One group shared 98% of the answers with their peers, while another group shared not more than 43%.

To what extent do the following reasons improve your motivation to prepare the seminar assignments?	*Mean (SD)*	*≥ 4 (%)*
I wanted to study the material before the upcoming multiple-choice exam	4.02 (0.93)	78.1
I realize that seminar assignments will be a useful training for the end-of-course exam	3.93 (0.99)	72.6
I wanted to compare my own answers to answers given by my peers	3.54 (1.09)	57.2
I wanted to know whether I could complete the assignments on my own before discussing them with my peers.	3.51 (1.03)	52.8
I did not want to let my peers down	3.40 (1.00)	50.6
I find the content of this course interesting	3.34 (0.99)	49.5
I did not want to rely completely on the answers of my peers, because these might be incorrect or incomplete	3.25 (1.13)	47.3
I did not want to be identified as a free-rider	3.08 (1.25)	45.1
I knew that our teacher would not provide us the correct answers, therefore I wanted to find out what the correct answer was all by my self	2.63 (1.21)	27.5
The seminar assignments were challenging and therefore I liked to prepare them	2.70 (0.98)	18.7
I knew that our teacher would (informally) check whether I had prepared the assignments.	1.92 (1.09)	11.0
To what extent do the following reasons decrease your motivation to prepare the seminar assignments?	*Mean (SD)*	*≥ 4 (%)*
I prefer to spend time on other (learning) activities than to prepare the assignments	3.20 (1.23)	46.2
Seminar assignments are too difficult to prepare individually	2.97 (1.10)	33.0
Assignments will be repeated twice during the seminar (once in discussion with peers and again during plenary discussion)	2.59 (1.19)	28.6
I did not plan to go to the seminar	1.98 (1.28)	16.5
I knew that the correct answer would be place on the wiki's	2.09 (1.12)	14.3
I planned to answers the assignment during the seminars	2.04 (1.11)	14.3
To me the assignment were not available in time	1.88 (1.23)	14.3
I knew the teacher would not provide us with answers or elucidations	2.06 (1.13)	12.2
I am not interested in the content of this course	2.12 (1.11)	11.0
My peer will immediately copy my answer	1.73 (1.11)	9.9
My peers will not take my answers seriously	1.36 (0.81)	3.3
I knew my peers would prepare the assignment, so there was no need to prepare them myself	1.63 (0.76)	2.2

Table 2. Motivating and demotivating reasons to prepare for seminars.

Perceived quality of the seminars

As shown in Table 3, students indicated that they were confident in finding the correct answers to the seminar assignments (all seminars were rated ≥ 4 by more than 50% of the students). Similarly, students reported that all seminars had deepened their knowledge. The second seminar was most satisfying, based on the percentage of students scoring a 4 or 5, when considering the average scores students were most satisfied with the fifth seminar.

	Confidence in answers		*Deepening of knowledge*	
Seminar	*Mean (SD)*	*≥ 4 (%)*	*Mean (SD)*	*≥ 4 (%)*
Resp 1	4.03 (0.94)	77.7	3.94 (0.79)	79.7
Resp 2	3.94 (0.77)	79.2	4.06 (0.72)	88.5
Circ 1	3.42 (1.10)	52.3	3.90 (0.80)	76.2
Circ 2	3.89 (0.73)	72.8	3.86 (0.79)	75.3
Uri 1	4.17 (0.85)	77.8	4.03 (0.81)	75.0
Uri 2	3.85 (1.02)	68.7	3.79 (0.90)	70.1
Uri 3	3.69 (0.96)	57.2	3.41 (0.95)	49.5

Table 3. Perceived quality of seminars
The perceived confidence in finding the correct answer and the perception that seminars deepened student knowledge were surveyed using an anchored scale ranging from 1 (very little) to 5 (very much). ≥ 4 (%) illustrates the percentage of students rating the Likert-items with a 4 or 5.

Table 4 shows students main arguments explaining their increased motivation to participate actively in seminars. The most important argument, according to 79% of the students, was that they wanted to keep track of the correct answers themselves, therefore not being too dependent on the wikis. Additionally, 69% of the students wanted to 'better understand the content by discussing with their peers' and 68% of the students wanted to be able to present the correct answer during plenary discussions. In general, no elements were found that were highly demotivating for active participation during the seminars, although the most demotivating factor was the repetition of the assignments during the actual seminar, according to 21% of all student.
From the subgroup of students, who choose not to attend the last three seminars, 9% identified that repetition of assignment was demotivating. However, not wanting to explain everything to (unprepared) peers was rated a 4 or 5 by 27% of this subgroup of students.

To what extent do the following reasons improve your motivation to participate actively in seminars?	*Mean (SD)*	*≥ 4 (%)*
I wanted to write down the correct answers myself, so I don't have to rely on the wiki's	3.99 (1.06)	79.2
I want to better understand the content by discussing with my peers	3.77 (1.02)	69.3
I want my subgroup to be able to present the correct answer during the plenary discussion	3.74 (0.92)	68.1
I wanted to be able to criticize the correctness and completeness of answers given by other subgroups	2.96 (1.02)	31.9
I knew the teacher would not provided us the correct answer, therefore I wanted to find out the correct answers myself	2.91 (1.12)	33.0
It was easier to ask the teacher for help, when the assignments were discussed with my peers	2.84 (1.15)	33.0
I expected that active participation would lead to goodwill of our teacher to provide us with additional clues	2.62 (1.16)	23.1
I wanted to find out which assignments should be discussed in the Meet The Expert session	1.68 (0.91)	4.4

To what extent do the following reasons decrease your motivation to participate actively in seminars?	*Mean (SD)*	*≥ 4 (%)*	*Mean (SD) students not attending*	*≥ 4 (%)*
I did not want to explain everything to my (unprepared) peers	1.91 (1.14)	12.1	2.36 (1.29)	27.3
Repetition of the assignments during the seminar; First in peer-discussion followed by plenary discussion	2.43 (1.16)	20.9	2.45 (0.93)	9.1
I knew that the correct answer would be placed on the wiki	1.98 (1.03)	7.7	2.18 (0.98)	9.1
I knew the teacher would not provide us with the correct answer	1.95 (1.04)	6,6	2.36 (1.21)	9.1
I am not interested in the content of this course	2.16 (1.07)	9.9	1.91 (0.83)	0
I knew my peers would prepare the assignments	1.90 (0.90)	5.5	1.73 (0.79)	0

Table 4. Motivating and demotivating reasons to actively participate in seminars. Students could indicate to what extent every argument for active participation applied to them using an anchored scale ranging from 1 (little contribution / little reduction) to 5 (large contribution/ large reduction. ≥ 4 (%) illustrates the percentage of students rating the Likert-items with a 4 or 5.

5

Relation between students' preparation and the quality of the seminar.

To explore if preparation predicts perceived quality of seminars, regression analyses was performed. As shown in Table 5a, model 1, perceived preparation of peers (B=0.18; p=0.02) could explain why students experienced that attending seminars deepened their knowledge (R^2=0.09, ΔR^2=0.07) and could also explain why students have confidence in having correct answers (B=0.40; p<0.01, R^2=0.21, ΔR^2=0.19) (Model 2).

	1. Deepening of knowledge				*2. Confidence in correct answers*			
Variable	*B*	*p*	*β*	*95% CI*	*B*	*p*	*β*	*95% CI*
Constant	2.94	.00		[2.34, 3.54]	2.16	.00		[1.50, 2.81]
Preparation time	.15	.06	.18	[-.01, .31]	.11	.21	.11	[-.06, .28]
Perceived preparation peers	.18	.02	.24	[.03, .33]	.40	.00	.44	[.24, .57]
R2	.09				.21			
ΔR2	.08				.20			

Table 5a. Regression analyses correlating variables of preparation with (1) deepening of knowledge and (2) confidence in correct answers. Perceived preparation of peers relates to deepening of knowledge and confidence in answers.

	Model 1				*Model 2*			
Variable	*B*	*p*	*β*	*95% CI*	*B*	*p*	*β*	*95% CI*
Constant	4.41	.00		[3.75, 5.07]	-1.98	.03		[-3.76, -.20]
N (seminars)	.34	.00	.45	[.22, .47]	.15	.02	.19	[.02, .27]
Previous achievements					1.10	.00	.60	[.81, 1.39]
R2	.20				0.48			
ΔR2	.19				0.47			

Table 5b. Regression analyses correlating exam scores with number of attended seminars. Number of seminars attended relates to (corrected) exam score.

	Model 1				*Model 2*			
Variable	*B*	*p*	*β*	*95% CI*	*B*	*p*	*β*	*95% CI*
Constant	6.84	.00		[4.93, 8.75]	-2.06	.12		[-4.67, .56]
Deepening knowledge	.03	.93	.01	[-.52, .58]	-.03	.90	-.01	[-.49, .43]
Confidence answers	-.17	.47	-.09	[-.64, .30]	.11	.63	.05	[-.33, .54]
Previous achievements					1.19	.00	.70	[.92, 1.46]
R2	.01				.48			
ΔR2	-.01				.46			

Table 5c. Regression analyses correlating exam scores with variables of participation. Deepening of knowledge and confidence in answers does not relate to exam scores. (B = regression coefficient, p= significance value, β = standardized coefficient, 95% CI = 95% confidence interval, R^2 = variance explained, ΔR^2 = adjusted variance explained.)

Relation between seminar attendance and exam scores

Table 5b indicates that the number of seminars attended is positively associated with end-of-course exam scores (B=0.34; $p<0.01$, $R^2=0.20$, $\Delta R^2=0.19$), even when corrected for previous achievement (B=0.15; $p=0.02$; $R^2=0.48$, $\Delta R^2=0.47$).

To further define the underlying mechanism, a model was tested in which ‘deepening of knowledge’ and ‘confidence in answers’ were used to predict exam scores (Table 5c). However, these results were not significant, suggesting that other variables may explain the higher grades when students attend more seminars.

Lastly, students were asked to describe how much they had learned from the seminars in general. Table 6 shows that approximately 37% of the students (N=34) explained they had learned from the seminars because they could compare and discuss their answers with answers given by peers. Also 21% report that seminars stimulated them to prepare and study the material before class. Additionally, 24% of the students elucidate they were stimulated to apply their knowledge in pathophysiology cases.

I learned from the seminars, because …	*N*	*%*
I was able to compare and discuss my answers to answers given by my peers	34	37.4
I was stimulated to apply knowledge in pathophysiology cases	22	24.2
Seminars stimulate me to prepare and study the material before class	19	20.9
I was encouraged to actively process the material	12	13.2
Content was rehearsed / I was able to practice	11	12.1
They prepared me for the exam	10	11.0
Subjects are discussed more elaborately compared to the lectures	6	6.6

Table 6. Students' explanations for learning from seminars Clustering of students' explanations why attending seminars were perceived useful. N = the number of students addressing each argument. Total number of respondents was 91. Some students provided multiple explanations. % represents the percentage of students that gave this explanation.

Teachers' perception

Teachers described the new design of seminars as an improved format, which stimulated students to prepare better. They all noticed that students participated more actively during group discussions, compared to students in previous cohorts. Still, teachers were concerned with the decreasing attendance rates.
Figure 2 illustrates how student preparation relates to the quality of seminars and that seminar attendance relates to exam scores.

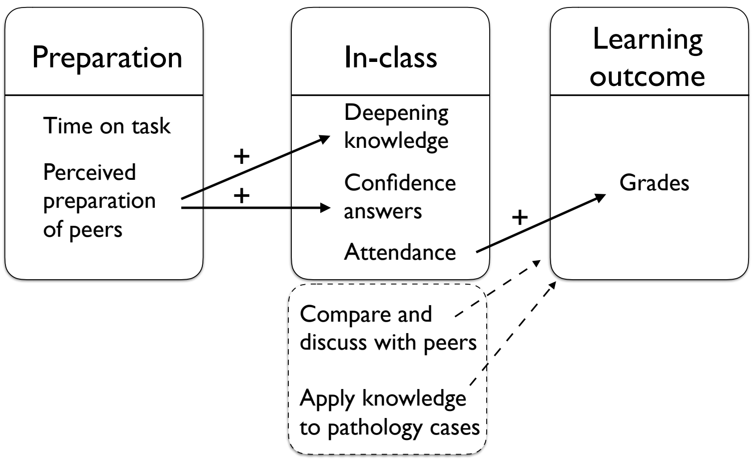

Figure 2. Model to illustrate the mechanism underlying student preparation, seminar attendance, and exam scores. Black arrows represent significant predictions (also indicated with '+'). Items in the dotted box represent factors that might have caused the improved learning outcomes according to students.

Discussion

The main findings of this study were that 1) seminar attendance is positively associated with exam scores, even when corrected for previous academic achievements and 2) perceived preparation of peers is associated with the perceived quality of seminars.

Preparation and peer-discussion

Students' preparation was relatively constant during this course, approximately 1.5 to 2 hours per seminar, whether or not they were able to complete their homework. This is an interesting finding, since a large part of the obtained learning effect might be determined by students' motivation to prepare[8]. The students participating in the present study claimed to be more motivated to prepare for the seminars because their performance in seminars could influence their autonomy. It seems that students use the seminar assignments to measure their own performance and compare this to a defined goal. This goal might be the level of understanding achieved by their peers, as students wanted to compare and discuss seminar answers with peers. Another goal might be the expected level of understanding required for the summative exam, as students used seminar assignments as training for the summative MCQ and end-of-course exams. These arguments correspond to the first of three scales of motivation identified by Aalbers, known as the 'urge to learn'-scale[8]. Alternatively, the argument best explaining our students' reduced motivation to prepare fitted nicely with Aalbers' second category, i.e. students 'lacked inner drive' as they preferred to spend their time differently. Aalbers' third category, expected difficulties, would correspond to students claiming that the assignments were too difficult. This third argument had a large contribution to 33.0% of students explaining their reduced motivation to prepare.

Preparation is known to be one of the keys to successful (seminar) learning[29] and appears to influence students' engagement in the educational activities. In seminars, engagement involves active participation in terms of peer-discussion and this requires peers to be sufficiently prepared as well. Overall, students (and teachers) were quite satisfied with the perceived preparation of peers, even though students deemed peers to be better prepared when a smaller number of students was able to finish the assignments individually. This suggests that poorly prepared students rely more on the contribution of peers. In contrast, if more students were able to complete the assignment, the preparation of peers was perceived as less satisfactory. These outcomes might imply that individuals within a group have different roles during peer-discussion. Confident students who completed their homework might function as '*information providers*' or '*assessors*' whereas others might be listeners or questioners[30]. These roles might be explained by the two kinds of social comparison that are described in literature, in which upward comparison is indicative for students feeling superior to peers (the information providers) whereas students feeling inferior to others (listeners) show downward comparison concerns[15]. Future research could look into these potential roles and investigate if these roles are related to self-efficacy and the preparation of the individual and their learning outcomes.

Active participation and learning outcome

In our study seminar attendance reduced substantially over time, even though students' motivations to actively participate were rather positive. The three arguments with the highest rating for increased motivation to participate actively were all related to peers. First, peers positively influenced participation, as they encouraged students to discuss the assignments with one another and this helped students to better understand the content. Second, the drive to be able to present the correct answer to peers during plenary discussion positively influenced students' participation. Nevertheless, students did not want to fully rely on their peers, as indicated with the third argument '*I wanted to write down the correct answers myself, so I don't have to rely on the wikis*'. This might be explained by the fact that actively participating students collected the correct answers during the sessions and refused to share their hard work with free-riders, i.e. peers whom did not attend the actual seminar but are able to collect the answers from the wiki's[31]. Reasons severely diminishing active participation were only acknowledged by a relatively small group of students suggesting that the real factor explaining students reduced participation and attendance has not yet been identified. Still, not wanting to explain everything to (unprepared) peers was considered most demotivating according to the subgroup of students who chose to not attend the last three seminars. On the other hand, it could be that seminar attendance dropped because students were studying for the end-of-course exam. However, in the final week of the course no in-class activities were scheduled to ensure sufficient preparation time for this exam. Another reasons for reduced attendance might be the Christmas holidays, which is usually between the 5th and 6th week of the course. This could also explain why more students attended the last seminar.

Unraveling the mechanism

Our findings show that perceived preparation of peers provides students with more confidence in finding correct answers and the perception of deepening knowledge (Figure 2). We expected that preparation time would also influence the quality of seminars, however this was not significant. A relation between participation variables (deepening of knowledge and confidence in answers) and exam scores could not be determined, indicating that other variables affecting participation are involved. One of these additional variables might be the fact that seminars stimulated students to apply their knowledge to pathophysiology cases, as indicated by students' explanation when elucidating why they had learned from seminars. Students also explained that the approach stimulated them to prepare better, although this was not measured in their self-reported preparation time. Students also explain that comparing and discussing seminars answers with peers (in buzz groups) was perceived very useful. However, it is interesting to notice that, when considering average scores, students were most confident in finding the correct answers and perceived to deepen their knowledge most during the fifth session (Table 3), which was attended by the lowest number of students (Table 1). This finding might be explained by the fact that teacher was 'more visible'. One teacher noticed that students were more inclined to ask questions in this particular session, whereas in later sessions, peers often answered student questions.

In future research applying knowledge to pathophysiology cases, discussing with peers and other variables such as intrinsic motivation or conscientiousness might be examined in order to further crystalize the mechanism underlying increased exam scores due to peer-discussion.

Limitations of this study

A threat to the validity of this study is selection bias, as the number of students participating in seminar learning substantially reduced over time. Since intrinsically motivated students are more likely to actively participate in educational activities, seminar attendance will obviously relate positively with exam scores. For that reason, we corrected exam scores with previous academic achievement, since we assume that the most motivated students in this course were more likely to be the more successful students in related courses.

Secondly, this study deals with student perceptions of the quality of seminars. It is therefore important to bear in mind that their perceptions are possibly biased by their own preparedness. Similarly, it might be difficult for students to distinguish between what was learned during seminars, and what was learned after the seminars when preparing for the exams. Still, self-reported learning outcomes are considered to be adequate and appropriate measures and are frequently examined in relation to other outcome measures, such as test scores[32].

Future directions

A practical implication of this study, more precisely of the format for seminar learning, is that there was too much repetition. Students actually revise the preparatory assignments (homework) twice during the actual seminar, and it is known that lengthy revision particularly decreases students' motivation to prepare[8]. A suggestion for future research includes providing students with preparatory homework consisting of relatively easy assignments followed by newly presented, and cognitively more complex assignments that will be discussed in buzz group formation such that students can demonstrate the facility and mastery of content. We anticipate that this adaptation might further improve preparation for and/or active participation in seminars.

Conclusion

In this study peer-discussion stimulated students to participate actively, resulting in improved quality perception. Consequentially, seminar attendance was positively associated with student performance on the summative exam, even when corrected for previous academic achievement. In addition, insight into students' motives to prepare for and participate in student-centered seminars was provided.

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Chapter 6

How do medical students prepare for flipped classrooms?

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Abstract

A flipped classroom, an approach abandoning traditional lectures and having students come together to apply acquired knowledge, requires students to come to class well-prepared. The nature of this preparation is currently being debated. Watching weblectures as a preparation has typically been recommended, but more recently a variety of study materials has been considered to serve students personal learning preferences. The aim of this study was to explore in two flipped courses which online study materials stimulates students most to prepare for in-class activities, to find out whether students differ in their use of study materials and to explore how students use of online study materials relates to their learning strategies.

In a basic science and a clinical course medical students were provided with weblectures, text selections, scientific papers, books and formative test questions or case studies. Use of these online materials was determined with questionnaires. All students watched weblectures and read text selections to prepare for in-class activities, but students differed in the extent to which they used more challenging materials. Additionally, the use of online study materials related to students' learning strategies that involved regulation and monitoring of study effort. Our findings suggest that students have similar learning preferences as they all use the same 'basic materials' to prepare for in-class activities. We interpret the preferential use of weblectures and text selections as being regarded as sufficient for active in-class participation. The less intensive use of other study materials may reflect students' perception of limited study time.

Introduction

Flipped classrooms are characterized by substantial pre-class preparation, while in-class time is focused on active student-centered learning activities[1-6]. In a flipped or 'inverted' classroom approach, students' pre-class preparation is intended to acquire knowledge and understanding for which a surface approach to learning, such as organizing and rehearsing[7], is sufficient. This acquired knowledge can then be applied during in-class time that is aimed at deep learning activities such as critical thinking and elaboration.

Even though a flipped classroom is a relatively new approach to education, recent publications start supporting its effectiveness. Some studies provide evidence showing improved performance for students learning in the flipped classroom compared to traditional (lecture based) classrooms[5,8-10], and others indicate that students are more satisfied[11-13]. Conversely, increased time-commitments and study load for students have been addressed[1,8,14].

As mentioned above, a prerequisite for successful flipped classrooms is that students have 'a prepared mind' when coming to class[14-17]. Without sufficient pre-class preparation knowledge cannot be applied in in-class activities such as analyzing data, solving problems or participating in in-class patient presentations[18,19].

The design of pre-class (and in-class) activities is currently being debated. Initial descriptions of flipped classrooms describe how students are provided with weblectures, either newly recorded videos by the teacher or recommended lectures from the internet, to learn new principles in their own time[14]. However, students have access not only to weblectures but often also to (online) textbooks and/or e-learning modules to facilitate pre-class preparation[1,5,6,14,20]. A variety of study materials has been considered to serve students personal learning preferences[6,8,21]. It is of interest to know whether providing weblectures as pre-class preparation would be sufficient for students in a flipped classroom to prepare for in-class activities or that additional materials are required.

This study aimed to explore to what extent students indeed use a variety of suggested online study materials to prepare for in-class activities in two flipped courses, a basic science course and a clinical course. We also aimed to explore whether students differ in their use of online study material. Finally, we aimed to understand how students use different study materials by exploring the relation between the use of materials and self-reported learning strategies. For this study we operationally defined the flipped classroom model as education in which content information on a factual level is processed outside the classroom, while elaboration and discussion of the materials is organized in a subsequent classroom meeting. Knowing what study materials students use, will provide insight in what activities students find most relevant to spend their time on and knowing what materials they use less might give an indication of what materials can lead to study burden. In addition, knowing what study materials students use most could help teachers in prioritizing what materials they design for their students in situations of limited available time. On the other hand, knowing what materials are related to deeper learning activities might support teachers in deciding on what materials are suitable for preparation and what materials are suitable for in-class activities.

Method

Educational setting

This study was conducted in two flipped classroom courses of one cohort of the graduate entry four-year undergraduate medical program at Utrecht University in the Netherlands. In this program class size is 40. The first course was a 4-week basic science Anatomy course, delivered in the first-year of the program (October 2013), and the second course was a 5-week clinical Rheumatology and Orthopedics course taught during the second year (November 2014). Both courses aimed for knowledge acquisition and conceptual understanding.

Pre-class & in-class activities

In the Anatomy course, all pre-class study materials were presented in a custom made iBook, and consisted of text selections on the topic (i.e. descriptions of general concepts of anatomy written by the teacher), weblectures, formative test questions, links to scientific papers and links to additional electronic books. Weblectures and text selections were provided as background information and covered basic principles. Understanding of these basic principles could be checked with formative test questions. More challenging materials such as scientific papers and books were made available to encourage students to elaborate and expand their knowledge.

The students were instructed to study materials of their choice so that in-class activities could be dedicated to adjacent and more complex principles, such as specification of concepts or comprehensive discussion of difficult elements. If necessary, basic principles were clarified at the beginning of each classroom meeting by a teacher who was content expert.

The Rheumatology and Orthopedics course had a similar set-up. Blackboard® gave access to weblectures, text selections (in this course consisting of textbook fragments covering the subject matter), case studies (i.e. patient presentations), links to electronic books and scientific papers. During in-class activities, case method teaching was applied, followed by discussion based on new case studies. A content expert teacher guided in-class activities.

Participants

Of the 40 students annually enrolling in the program, 38 participated in this study during the 2013-2014 Anatomy course and 25 students participated in the 2014-2015 Rheumatology and Orthopedics course. These students were on average 24.0±3.5 years old, and 60% (23) were female. In total 25 students (63%) participated in both studies.

All participating students signed informed consent forms providing them with information about the goals and data handling methods of each study. Participation was voluntary and no incentives were given. The Ethical Review Board of the Netherlands Association for Medical Education (NVMO) approved these studies separately (# 284 and # 397).

Data collection

Self-reported use of online study materials

In both courses, learning instructions stressed that pre-class preparation was essential in order to make in-class activities successful. Students were instructed that they could choose whichever materials they preferred to use to prepare for classroom meetings. None of the information sources were presented as mandatory.

To determine students’ use of online study materials, all participants were invited to fill out a weekly questionnaire including items with 5-point Likert scales as to what extent they used which online study materials when preparing for the in-class activities. Participants were also asked to explain why they perceived their three most extensively used study materials to be supportive, in an open-ended question format. In the Rheumatology and Orthopedics course, after the collection of data of open-ended questions, closed-questions were formulated asking students to what extent they agreed with the arguments explaining why online study materials are perceived as supportive.

Learning strategies

The following nine learning strategies were measured using the following scales

of the Motivated Strategies for Learning Questionnaire, MSLQ[7]: *Rehearsal, Elaboration, Organization, Critical thinking, Self-regulation, Time management, Effort regulation, Peer learning and Help seeking.* All 50 items in the 9 learning strategy scales were translated into Dutch. To determine the reliability of the translated items, 25 volunteers studying in different (bio) medical graduate programs filled out this questionnaire. All items were to be rated on a Likert scale ranging from 1 (Not at all true of me) to 7 (Very true of me).
The reliability of the nine scales was determined using Cronbach's alpha. If Cronbach's alpha was below 0.65, individual items were inspected for clarity and adapted to improve the scale. This led to rephrasing two items of the scale *Effort regulation*.

At the end of both courses the questionnaire was administered to measure students' self-reported learning strategies. Scale scores were constructed for each of the 9 learning strategies.
For each learning strategy scale normality was inspected using histograms. All scales, except for *Critical thinking*, appeared distributed normally. The distribution of *Critical thinking* showed a rather dichotomous pattern, suggesting two subgroups (those who do and do not indicate to think critically). Therefore, the mean scores for this scale were transformed into a dichotomous variable.

Analyses

Self-reported use of online study materials

Due to missing data 3 and 5 participants were excluded from the Anatomy and Rheumatology and Orthopedics course respectively. Open-ended questions in which students explained why they perceived their three most extensively used study materials to be supportive were grounded categorized. Items with 5-point Likert scales as the use of online study materials and the agreement with explanations for perceived supportiveness of study materials were analyzed by inspection of means and standard deviations.

Differences in study material use

To investigate whether students differed in the study materials they used K-means cluster analysis was applied[22]. In the Anatomy course 1 additional student was excluded due to one missing data point. We started with interpreting the 3, 4 and 5 cluster solutions, but these results showed only two meaningful clusters of students could be distinguished.

Relation between self-reported use of study material and learning strategies
To explore how the use of online study materials related to self-reported learning strategies, bivariate correlation analysis was performed. The correlations between study material use and eight learning strategies, '*Rehearsal, Elaboration, Organization, Self-regulation, Time management, Effort regulation, Peer learning* and *Help seeking*', were analyzed for both the Anatomy and the Rheumatology and Orthopedics course. Because the number of correlations that were analyzed was rather high (40 correlations per analysis), a conservative p-value was used for significance (P<0.01). As *Critical thinking* was considered a dichotomous variable, the two subgroups were compared on their use of study materials using ANOVAs.

Results

Learning strategies	*Sample question*	*K*	*α Anatomy (N=38)*	*α Rheumatology Orthopedics (N=25)*	*K*	*α Anatomy (N=38)*	*α Rheumatology Orthopedics (N=25)*
		Complete			*Optimized*		
Rehearsal	I make a list of important terms for this course and memorize the lists.	4	.66	.67	4	.66	.67
Elaboration	When reading for this class, I try to relate the material to what I already know.	6	.57	.64	4	.65	.74
Organization	I make simple charts, diagrams or tables to help me organize course material.	4	.81	.78	4	.81	.78
Self-regulation	I try to change the way I study in order to fit the course requirements and the instructor's teaching style.	12	.78	.61	11	.78	.65
Time management	I make good use of my study time for this course.	8	.84	.84	8	.84	.84
Effort regulation	I work hard to do well in this class even if I don't like what we are doing.	4	.84	.80	4	.84	.80
Peer learning	I try to work with other students from this class to complete the course assignments.	3	.74	.74	3	.74	.74
Help seeking	I ask the instructor to clarify concepts I don't understand well.	4	.65	.35	3	.69	.69

Table 1. Reliability of learning strategies. Names and sample questions for each learning strategy are shown, K is the number items included per scale. First reliability of the complete scale is depicted, followed by optimized reliability scores.

Reliability of learning strategies

Table 1 shows the reliabilities of eight learning strategies. If necessary, we aimed to improve Cronbach alpha's to ≥0.65, while maintaining as many items as possible and using identical scale-items for both the Anatomy and the Rheumatology and Orthopedics course to allow for comparisons. Based on the results in the Anatomy course, two items in the *Elaboration* scale were removed to increase the alpha from 0.57 to 0.65.

The *Self-regulation* and *Help seeking* scales initially showed low reliabilities in the Rheumatology and Orthopedics course (alpha = 0.61 and 0.35 respectively). Deleting one item optimized these scales to 0.65 and 0.69 respectively.

Self-reported use of study materials

Table 2 shows that in both courses, students prepare for in-class activities predominantly by watching weblectures and reading text selections. In addition, formative test questions in the Anatomy course and case studies in the Rheumatology and Orthopedics course were the third most frequently used tools to prepare for in-class activities.

	Anatomy (N=35)	*Rheumatology, Orthopedics (N=20)*
	Mean ± SD	*Mean ± SD*
Weblectures	4.26 ± 0.98	4.55 ± 0.69
Text selections	4.37 ± 0.49	4.05 ± 1.05
Formative test questions	4.09 ± 1.04	n.a.
Case studies	n.a.	3.95 ± 1.00
Additional books	2.83 ± 1.32	3.45 ± 1.36
Scientific papers	2.41 ± 1.18	2.35 ± 1.39

Table 2. Mean use of online study materials. For each online study material mean self-reported use and standard deviation are shown. Scale ranged from 1 to 5.

Perceived supportiveness of weblectures, text and formative test questions or case studies

In the Anatomy course, students reported that weblectures were supportive to prepare for in-class activities because they consisted of a clearly explained summary of the content that could be paused and repeated as many times as preferred. Additionally, in the Rheumatology and Orthopedics course, students indicated that weblectures provided a clear overview of the most important topics (4.10± 0.77),

which can be viewed at their own pace (4.43± 0.60).
Text selections were perceived as a summary of the content that helped students to distinguish essentials from ancillaries in the Anatomy course. Interestingly, in the Rheumatology and Orthopedics course contradicting answers were given regarding text. In open-ended questions students described that text selections did provide them with an overview, but they rated this characteristic rather low in the closed questionnaire (2.25±1.25). They also claimed that text selections were too extensive (4.30±1.33).

Formative test questions, available in the Anatomy course, were found to be supportive as students indicated that these questions helped them to check their understanding of particular subjects and students appreciated that it is an interactive learning tool. In the Rheumatology and Orthopedics course, formative tests were not available, but instead students could apply their knowledge by solving case studies (4.14±0.73). Students reported that these case studies also helped them to focus their study effort (3.52± 1.03).

Differences in study material use

Cluster analysis indicated that two groups of students could be distinguished based upon their self-reported study material use, referred to as A and B. Table 3 shows that in both courses, group A and B extensively watched weblectures and read text selections. In addition to these basic materials, students in group A_A used more formative test questions, read more scientific papers and additional books, compared to group B_A. In the Rheumatology and Orthopedics course, both groups also used case studies to prepare for in-class activities. Students from group A_{RO} read more scientific papers and studied additional books more intensively, compared to group $B_{RO.}$ In addition, students from group A_{RO} seemed to read text selections more extensively, but this difference was not statistically significant (p=0.052). Students that clustered to group A in the Anatomy course did not necessarily cluster to group A in the Rheumatology and Orthopedics course.

Study material	Anatomy (A_A) N=19 (50%)	(B_A) N=15 (39%)	F	Rheumatology, Orthopedics (A_{RO}) N=10 (40%)	(B_{RO}) N=10 (40%)	F
Weblectures	4.26	4.20	0.03	4.60	4.50	0.10
Text selections	4.32	4.40	0.25	4.50	3.60	4.31
Formative test questions	4.47	3.53	8.33*	n.a	n.a	n.a
Case studies	n.a.	n.a.	n.a.	4.20	3.70	1.27
Additional books	3.58	1.73	35.74*	4.40	2.50	19.23*
Scientific papers	3.05	1.60	19.83*	3.30	1.40	17.56*

*Table 3. Difference in study material use Mean use of study material per cluster in the Anatomy course (A_A and A_B), and the Rheumatology and Orthopedics course (A_{RO} and B_{RO}) are shown. Scale ranged from 1 to 5, *= P<0.05.*

Relation between self-reported use of study material and learning strategies

Two significant correlations were found for reading text selections. As shown in Table 4a and 4b, in the Anatomy course (see Table 4a) reading text selections was positively related to *Effort regulation* (i.e. ability to control study effort and committing to personal goals), suggesting that students who read more texts, also reported to be committed to finish homework before class. Additionally, a positive correlation between text selections and *Rehearsal* in the Rheumatology and Orthopedics course (see Table 4b) suggests that students that read more texts also reported to rehearse more when studying.

Additionally, two correlations were found for the learning strategy *Self-regulation*. In the Anatomy course, a positive correlation was found for the use of scientific papers with *self-regulation*. Suggesting that students who report to be less aware of their own cognition read less scientific papers. However, it must be noted that students hardly read additional papers in general, as shown in Table 2.

In the Rheumatology and Orthopedics course, even though all students watched weblectures, as shown by the high mean and small standard deviation in Table 2, the more students reported to watch weblectures, the more they report to apply *Self-regulation* (i.e. the ability to plan and monitor a task; see Table 4b).

Interestingly, no significant correlations were found between learning strategies and use of formative test questions, case studies or additional books.

The two ANOVAs comparing the two subgroups for *Critical thinking* showed no differences in terms of their use of online study materials. In the Anatomy course P-values were between 0.195 (F= 10.59) for text selections and 0.971 (F=3.73) for scientific papers. In the Rheumatology and Orthopedics course p-values ranged from 0.111 (F=2.78) for text selections and 0.818 (F= 0.83) for case studies.

Discussion

The prerequisite for a successful flipped classroom approach is that students are well prepared for participation in in-class activities. This exploratory study gives insight into the students' predominant use of pre-class study materials. All students use weblectures and text selections extensively. Other tools such as case studies and formative test questions are used as well, but these seem to be used to a lesser extent. When preparing for in-class activities, watching weblectures related to *Self-regulation*, and reading text selections related to *Effort regulation* or *Rehearsal*.

Extensively used study materials

In the flipped courses weblectures were designed to provide students with background information and to teach basic principles. Therefore, intensive use of weblectures while preparing for in-class activities was perhaps not surprising. Students appreciated that weblectures could be viewed at their own pace, which is in line with other studies regarding the use of weblectures[23]. Moreover, weblectures provided students with an overview of the most important topics, which is supported by the fact that the use of weblectures was related to students' self-reported ability to plan and monitor their learning.

The second most extensively used online study material was text selections. Students participating in this study have indicated that text selections helped them to summarize the content and to distinguish essentials from ancillaries. Moreover, correlation analyses suggest that information covered by text selections helped students to regulate study effort when preparing for in-class activities. However, when text selections are perceived to be too extensive, students will miss overview of the content. This might explain why students rehearsed more.

Finally, formative test questions, case studies and additional study materials such as scientific papers and books were provided to stimulate students to elaborate and encourage them to think critically. However, relations between the use of these more challenging study materials and cognitive more complex learning strategies (i.e. *Elaboration* and *Critical thinking*) were not found. Students' choice to mainly prepare with 'basic materials' (weblectures and text) might be explained by the fact that students perceived to be overloaded, as indicated by comments in the end-of-course evaluations.

Anatomy	*Rehearsal*	*Elaboration*	*Organization*	*Self-regulation*	*Time management*	*Effort regulation*	*Peer learning*	*Help seeking*
Mean ± SD	4.63±1.25	4.95±0.94	4.88±1.45	4.58±0.92	5.19±1.13	5.16±1.34	3.14±1.32	4.15±1.48
Weblectures	-0.018	-0.026	-0.065	0.015	0.224	0.210	-0.210	-0.078
Text selections	0.000	0.243	-0.150	0.270	0.428	0.485*	-0.264	-0.156
Scientific papers	0.326	0.205	0.198	0.520*	0.257	0.367	0.099	0.163
Formative tests	-0.125	0.063	-0.113	0.056	0.148	0.132	-0.225	-0.128
Additional books	0.026	0.045	0.233	0.227	0.050	-0.019	-0.021	-0.049

Rheumatology, Orthopedics	*Rehearsal*	*Elaboration*	*Organization*	*Self-regulation*	*Time management*	*Effort regulation*	*Peer learning*	*Help seeking*
Mean ± SD	4.56±1.20	5.08±0.96	5.24 ±1.32	4.54 ±0.70	4.66 ±1.08	4.70 ±1.33	3.19±1.25	4.28±1.13
Weblectures	0.489	0.116	0.528	0.655*	0.173	0.070	0.186	0.168
Text selections	0.708*	-0.101	0.340	0.549	0.419	0.453	-0.214	-0.055
Scientific papers	0.196	0.162	-0.005	0.257	0.308	0.315	0.052	0.218
Case study	0.516	-0.066	0.336	0.417	0.481	0.369	-0.038	-0.214
Additional books	0.338	-0.117	0.094	0.089	0.314	0.237	-0.400	-0.464

Table 4a and b. Relation between study material use and learning strategies
*Use of study materials while preparing for in-class activities relates to self-reported learning strategies in the Anatomy (4a) and Rheumatology and Orthopedics (4b) course. Significant correlations are indicated with *= P<01.*

Differences in study material use

Street et al. argued that students have different learning preferences and that therefore various study materials should be provided to students[8]. However, our findings indicate that all students use the same 'basic materials' to prepare for in-class activities and that half of the students used additional materials. We thus did not find that students seem to have preferences for different study materials, but mainly differ in the extent to which they use more challenging materials in addition to the basic materials. Also the fact that students' individual use of materials was not consistent between the two courses does not support the notion of students having personal learning preferences.

With respect to the issue of whether providing weblectures as pre-class preparation would be enough for students in a flipped classroom to prepare for in-class activities, our findings suggest that weblectures are important. We showed that students intensively used this material to prepare for in-class activities, similar to reading text selections. However, since 40% to 50% of the students chose to combine these 'basic materials' with scientific papers, books and formative test questions (if available), our data do not support the idea that weblectures alone are sufficient to prepare for student-centered in-class activities. Neither do our findings support the hypothesis that students use a selection of the available learning materials to accommodate their personal learning preferences. Therefore, it is advised to provide students clear study directions to prevent undue study load and time commitments.

Relation between self-reported use of study material and learning strategies

In the Anatomy course three moderately strong correlations were found ($r>0.4$), whereas twelve moderate or strong correlations were detected in the Rheumatology and Orthopedics course. Interestingly, the strongest correlation involving the use of text selections and rehearsal observed in the clinical course was absent in the basic science course. One of the underlying causes might be the nature of these text selections. In the Rheumatology and Orthopedics course revising text selections could contribute to students understanding of the content, whereas the text selections in the Anatomy course could do this to a lesser extent as they related to more general concepts. Another explanation might be that students adapt their learning strategies when learning different subjects. This is in line with the findings of Rotgans and Schmidt, who showed that learning strategies are context-specific and, therefore, large within-person variations can be measured across different disciplines[24].

Study limitations

While our results provide useful information for selecting extensively used study materials, a number of limitations should be addressed. First, the small number of students participating in this study together with the large number of correlations that were reported to explore the relation between students' use of study materials and their learning strategies affect the generalizability of the results. This approach may have led to capitalization on chance, even though a conservative p-value of ≤0.01 was used to determine statistically significant differences. Therefore, to validate our conclusions this study should be replicated in larger and more heterogeneous samples.

Second, to explore to what extent study materials were used, questionnaires were composed of Likert-scale questions. This provided information about the self-reported relative use of study materials, although it is not addressed specifically how much time students spend using the different materials. Future research might focus on this to investigate to what extent flipping the classroom does affect time-commitment and to determine to what extent study load does increase when a larger variety of study materials is available as anticipated by Moffett[1] , Prober[14] and Street[8]. This will provided insight into the relation between students perceived and experienced study load.

A third limitation concerns the fact that offline study materials were not included in this study. This decision was made because this study aimed to distinguish which *online* study materials are used most frequently, since the online materials are the materials provided by teachers. This is important because it is known that flipping the classroom requires a large time and effort investment from the teachers[1].

Study strengths

Our study has a number of strengths. It describes student preparation in two distinct courses (a basic science and a clinical course) in which students predominantly used the same study materials. This suggests that the findings are robust for at least our population. In addition, to the best of our knowledge this was the first study to explore differences between the materials that students use to prepare and the relation between students' preparation and their learning strategies. Therefore, this study has provided some first insights into these issues but also yielded directions for future research.

In conclusion, students do not seem to differ a lot in how they prepare for in-class activities as most students seem to prepare by watching weblectures and reading text selections. Additionally, approximately half of the students do use formative test questions, scientific papers and books next to these basic study materials. Unexpectedly, these cognitive challenging study materials were not related to deep learning strategies. Instead pre-class preparation using weblectures and text selections related to learning strategies that involve regulation and monitoring of study effort.

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Chapter 7

What do teachers do differently during a flipped classroom?

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Abstract

Introduction Educators have stressed the virtues of small group, (inter)active and student-centered education. A relatively new approach to move away from large lectures with passive listeners is the flipped classroom (FC). FCs are considered to induce increased levels of engagement, improved performance and more student satisfaction. What we do not know is what actually happens inside the classroom when flipping is applied. This study aims to compare and contrast teacher and student activities in regular and flipped classrooms.

Method In this observational study we compared in-class activities before and after implementation of FCs, led by the same teachers, dealing with similar topics in consecutive cohorts of students. Audio recordings were made of five regular classrooms and five FCs. The qualities and duration of teacher and student activities were calculated as percentages of total classroom time and compared across both cohorts.

Results In FCs, teachers spent less time explaining factual information, more time providing feedback to students and more time asking questions. Consequentially, more time was left for students to respond to questions. The percentage of time explaining in-depth information by teachers and the percentage of time asking questions to the teacher were comparable in both conditions.

Conclusion These findings suggest that FCs do increase in-class interactivity and stimulate student engagement. FCs provoke teachers to ask more questions and students to respond. Our findings should be replicated in different courses and context.

Introduction

For decades educators have stressed the virtues of small groups, active learning, student centered education and interaction in higher education, and in medical education specifically[1-6]. The relatively new concept of *flipping the classroom (FC)* has provided new energy to a move away from large lectures with passive listeners[7,8]. In the FC concept, what is normally done in class and what is normally done as homework is switched or flipped. FCs purportedly lead to classroom time being used more effectively and creatively, resulting in increased levels of student achievement, interest, and engagement, more student thinking inside and outside of the classroom and students being more actively involved in the learning process[9]. New is the technology component in how students prepare for classes. Our experience is that e-lectures, next to readings in the online learning environment, are indeed preferred materials if students can choose how to prepare for FC sessions[10].

What we do not know is what precisely happens inside the classroom when the flipping is applied. The literature suggests that FC changes the nature of lectures. However, many medical education programs now have more small group teaching than lectures, and active, student centered teaching has been a rule rather than an exception, since long before the era of educational technology. A question is therefore: does FC change the behavior of teachers and students, even in courses that already apply student-centered, active, small group learning? Or, to put it differently, how do the teaching and learning processes change when teachers are asked to redesign their lessons in a FC manner? Elaborated plans of classroom activities have been designed and have shown to meet with appreciation by students in course evaluations[11], but actual interactional dynamics in the classroom have not been reported.

We conducted a controlled observational study to investigate how interaction dynamics change if teachers are asked to change lessons from a regular format, as they have been applying for several years, to a FC approach. We focused on the type of interactions that take place in the classroom. Our expectations were that teacher behavior would change from a predominantly information providing and instructional approach to a more responsive and questioning approach[12,13]. This led us to assume that flipping the classroom would enable more teacher-student interactions and that teachers would provide more feedback to students. The aim of this observational study was to ground the hypotheses regarding teacher-student interactions that can be tested in future studies.

Methods

Context

The study was conducted in a four-year graduate-entry medical course at the University Medical Center Utrecht, the Netherlands. The lessons that were studied covered the following topics: *Introduction into oncology, Radiotherapy treatment of mamma carcinomas, Introduction into hematological oncology, Coagulation disorders* and *Anemia.*

Design

Classroom verbal utterances by teachers and students during 1-hour sessions were recorded and compared before and after the introduction of FC (2013-14 and 2014-15 respectively). The lesson content, classroom size and teacher were similar across both years; the student cohorts and instructions for teachers and student differed. The outcome measures were the patterns of interaction by the teachers and students in either condition.

Populations

Every year, 40 students enroll the four-year graduate entry medical training.
The student cohort entering the hematology and oncology course in 2013-14 contained 38 students, on average 24.1 ± 3.6 years of age; 64% were female. In the subsequent cohort (2014-15) the 41 students were 23.1±1.1 years of age and 67% were female.
The teacher population was limited to those five teachers who delivered similar lessons (as to their content) across both years and who were actively involved in creating e-lectures and rethinking their classroom activities.

Instructional intervention

All teachers delivered the lesson in the regular, familiar fashion in 2013-14 as they had done for the previous years. In the regular format students we expected to participate actively in class. As homework students were expected to read books and to process the content. Cases were made available for students for thorough understanding. Solving these cases was not obligatory.

Teacher instructions to flip their classroom were limited to two key aspects.
First, point of departure is the presumption that students have completed the preparatory homework. Second, classroom activities should engage students to apply the acquired knowledge. Case based teaching was recommended, although teachers were allowed to use other suitable interactive teaching methods.

In 2014-15 students were provided with e-lectures on factual information concerning the topic, to be studied as pre-class study material. Cases, similar to those available in the regular classroom approach, were most frequently used to achieve application of acquired knowledge in class.

Data collection

A researcher (RB) was silently present and made audio recordings of lecture-based regular and flipped classrooms. The main focus was to identify the interaction between teachers and students. Student-student interaction was regarded as one of the possible student activity. Classrooms sessions with real-life patient cases were excluded because of patient privacy.

Types of interactions

Based on literature readings[14] and discussion with three researchers (RB, RdK and OtC), a protocol for analysis was designed. The following in-class activities were expected for teachers: (1) Transmitting factual information, i.e. information that students should know by heart, that is covered in books (and e-lectures) and that is easily reproducible for the student population, (2) Explaining in-depth information, i.e. information that students should understand after application of their previously acquired knowledge in case presentations, and information that is known by medical professionals such as co-morbidities, (3) Asking questions to the student, (4) Answering student questions, (5) Providing feedback, i.e. giving directions to student thinking and supplementing student answers and (6) Giving instructions i.e. non-content procedural information.
For students three activities were distinguished; asking questions, responding to questions, and discussing with peers. Silence was also measured.

Audio recording analyses

Audio recordings were used to measure the duration of each activity in seconds. Each activity was labeled with one of the above-mentioned teacher or student activities. For each activity, the percentage of total class time was calculated. Significance testing was not conducted as we aimed at grounding hypotheses and because we considered the number of included classrooms too low.

An independent researcher (TvH) performed an audit procedure to determine whether the duration of each activity was measured accurately and whether the correct label was applied[15]. The auditor checked audio recordings of one regular and one flipped classroom. In his report, the auditor acknowledged that the duration of each activity was measured correctly and that activities were logically labeled. The auditor did find it difficult to distinguish the transmission of factual information from explanation of in-depth information, especially when medical professionals referred to personal experience when explaining general concepts. The auditor report is available upon request.

Ethical consideration

This study was part of a larger study, which was approved by the Ethical Review Board of the Netherlands Association for Medical Education. However, the ethical approval concerned students only. Teachers were individually asked to approve the recording of their lectures. Teachers were informed that recordings were solely used for research purposes and that data would be anonymised before discussion of the results with the research team. Five teachers gave permission.

Results

Audio recordings of five regular classrooms and five FCs were analyzed. On average, regular classrooms were 48 minutes (range 31-58 minutes) and FCs were 53 minutes (range 43-64 minutes). In total, 45 to 235 activities were measured per regular classrooms, which reflect 2.5 different activities per minute on average (range 1.4-4.3). In FCs, 128 to 299 activities were measured per classroom, reflecting 4.7 different activities per minute (range 3.0-6.2).

Regular classrooms

Table 1 shows that teachers in regular classrooms spent approximately 37% of the total classroom time transmitting factual information and on average 41% on explaining in-depth information. Asking questions, providing feedback and giving instructions to students took one, two and two percent of the total classroom time, respectively. In addition, students asking questions occupied 4% of classroom time, and teachers spent 10% of the total classroom time to answers these questions.

Flipped classrooms

In FC 18% and 32% of the total classroom time was spent explaining factual and in-depth information, respectively. Approximately 10% was used answering student questions, 9% asking questions to students and providing students with feedback occupied ±11% of the classroom time. Students spent approximately 5% and 6% of the total classroom time asking questions and responding to questions posted by the teacher, respectively.

	Regular classroom		*Flipped classroom*	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*
Teacher activity				
Transmitting factual information	36.8 (24.3)	10.2-65.7	18.3 (13.7)	6.1-33.5
Explaining in-depth information	41.1 (32.6)	4.5-75.4	31.8 (12.8)	23.9-54.3
Asking questioning	1.3 (1.5)	0.1-3.2	8.9 (3.3)	5.7-13.3
Answering questions	10.0 (2.5)	7.5-13.4	10.4 (3.4)	5.9-15.3
Providing feedback	2.0 (2.3)	0.0-5.8	10.6 (5.6)	4.7-19.6
Giving instruction	2.3 (2.7)	0.3-6.9	5.2 (1.2)	3.5-6.8
Silence	1.7 (1.2)	0.5-3.1	4.1 (4.3)	0.2-10.9
Student activity				
Questioning	4.0 (1.6)	2.0-6.0	4.6 (1.0)	3.7-6.2
Responding	0.9 (1.0)	0.0-2.4	5.5 (3.8)	1.8-11.7
Discussing	0.0 (0.0)	0.0-0.0	0.6 (1.3)	0.0-2.9
Total	100.1%		100%	

Table 1. Descriptive statistics of teacher and student activities (in percentage of total class time).

Discussion

Knowing what actually happens inside the classroom when flipping is applied might help to understand how outcome measures such as improved performance and student satisfaction are related to the educational approach. In this observational study, in-class activities were compared before and after the implementation of FCs that were led by the same teacher. On average, teachers appear to spend less time transmitting factual information whereas time spent explaining in-depth information was comparable to the regular classrooms. Overall, interactivity was increased since teachers asked more questions, students responded more and students were provided with more feedback. These findings demonstrate that teachers show different in-class behavior after the instruction to apply a flipped classroom approach.

Justification for measured classroom activities

A few observational studies have been described and most of them focus on students and their classroom behavior[14]. Nunn studied the correlation between discussion-related teaching techniques and student participation[16]. Asking questions was the most frequently used technique and resulted in increased participation of students. Other techniques such as praising students and correcting wrong answers were used to a much lesser extend.

In the current study praising students and correcting answers was interpreted as providing students with feedback. Providing students with frequent feedback is assumed to positively influence student learning in flipped classrooms[11,17]. In addition, the literature describes that flipped classrooms aim to engage students in interactive application of knowledge using deep learning activities[18-20]. To that end, students are stimulated to think critically, rather than only acquiring factual knowledge in the classroom[10,12]. To explore the more deep learning purpose of flipped classrooms we aimed to distinguish transmission of factual information from explanation of in-depth information. Asking questions and responding to questions by teachers and by students and active discussions with peers were used as proxy measures for interactivity. Besides these 'aim-related' activities teachers gave students instructional information and periods of silences were observed.

In-depth questioning

Besides the distinction of teacher explanations (factual versus in-depth information), looking into the type of questioning at the various Bloom levels of educational objectives[21,22] could provide an additional argument that flipped classrooms can result in deeper learning. These levels were not easy to determine in interactions observed in the current study. Both in regular and in flipped classrooms, students mainly wondered about co-morbidities in patients. And in contrast to flipped classrooms, teachers hardly asked questions in regular classrooms, therefore actual comparison of the type of questions was not possible.

Limitations

One methodological limitation to this study is that the data might provide an underrepresentation of the actual interactivity of flipped classrooms. Due to the fact we focused on lecture-based classrooms, we decided not to record the most interactive classrooms using buzz groups. In these sessions, students were discussing cases in small groups of 6 to 8 students. The teacher was simultaneously guiding multiple small groups of students. This teaching method closely resembled seminar learning and/or problem-based learning sessions[23,24]. The interactivity in these sessions was much higher compared to the regular classrooms. But the problem is that we cannot ascertain if this is the consequence of flipping, or if this is due to the alternative teaching method.
A second limitation to this study is that we did not look into the richness of conversations. Richness of conversation is an alternative approach to determine interactivity and might be explained as the amount of student participation. This could be measured as either the number of different students who spoke, or the

number of actions per conversation[16]. In flipped classrooms it is expected that both the number of participants and the number of actions within a conversation will increase, since assimilation information and critical thinking require in-depth understanding. Group-discussions and feedback from the content expert are expected to stimulate student learning.

Strength

Measuring the length of every activity on audio recordings provided a clear insight into the interactivity of flipped classroom discussions. Since we had the opportunity to compare regular and flipped classrooms regarding identical content and teachers, we were able to demonstrate that case-based learning in flipped classrooms is an effective method to achieve more teacher-student interactions.

Future research

Thus far, measurements have focused on short-term outcomes whereas long-term effects are not yet determined. For instance, it is not known whether students acquire more knowledge in flipped classrooms and / or if this knowledge is better retained. Future research could look into this to establish if the efforts for transforming regular classrooms into flipped classrooms is effective. Finally, our study was restricted to a single school and does not necessarily translate to other contexts. Replication of our study in different courses and contexts is recommended.

Conclusion

The findings suggest that flipped classrooms do increase in-class interactivity and stimulate student engagement. Flipped classroom appear to provoke teachers to ask more questions and students to respond.

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Chapter 8

Teacher expectations versus teacher experiences about flipped classroom teaching

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Submitted

Abstract

Introduction Since flipped classroom is a relatively new approach, publication bias towards positive experiences from frontrunners cannot be ruled out. Therefore, to implement flipped classroom on a large scale, it is important to both address teachers' unrealistically high expectations and/or hesitations. This study aimed (1) to identify teacher expectations of blended learning in general and (2) to investigate whether experiences with flipped classroom teaching met these expectations.

Methods After attending a workshop on blended learning, 87 university teachers completed a survey to identify expected opportunities and challenges of blended learning. Additionally, eleven other teachers were interviewed after teaching a flipped classroom. Survey results were transformed into a coding scheme to subsequently analyze the interview transcripts and to determine concordance of teacher expectations of blended learning with teacher experiences with flipped classroom teaching.

Results and conclusion The expected opportunities and challenges largely matched the experiences of flipped classroom teachers. Increased workload for students and teachers was an important theme in both expectations and experiences. Student preparation seemed the bottleneck for successful flipped classrooms. When students were adequately prepared, meetings were more interactive, discussions more in-depth and teachers more enthusiastic. Teacher solutions to encountered challenges and additional suggestions from literature are discussed.

Introduction

E-learning slowly integrates into traditional lecture-based higher education. This mixture of e-learning and face-to-face education is known as blended learning and is a frequently studied subject in educational research[1-7]. Blended learning creates the opportunity to introduce new teaching concepts. A flipped classroom is one particular teaching concept made possible by blended learning. In flipped classrooms the educational activities that traditionally occur in the classroom and the subsequent homework activities are reversed[8-10]. This means that students gather basic knowledge at home, for instance, by watching web-lectures, and apply this acquired knowledge in class under the guidance of a content expert.

The current literature on flipped classrooms shows that (under)graduate students appear to prefer this innovative teaching method over the traditional lecture-based methods[3,11-14], and that this new method can result in improved student performance[15-17]. Reported concerns in flipped classrooms are increased time-commitment and study load for students[8,9,15,18]. For teachers, time and effort is required to transform traditional education into flipped classroom courses[19]. Teachers often accept this, mostly because it is assumed that the newly developed learning resources can be used in consecutive courses and the increased effort is only temporary[9,12,20].

Because a flipped classroom is a relatively new approach, reports may have a tendency to show the positive experiences of pioneers and early adopters who are likely to already believe in this innovation[8,10,11,21,22]. Thus, we cannot rule out a certain publication bias. It may well be that (other) concerns teachers have, have not reached the literature yet. To implement flipped classrooms on a larger scale, it is necessary to address hesitations that may be based on possibly unjustified expectations, to address concerns about increased workload, to prevent disappointments caused by unrealistically high expectations, but also to reinforce real benefits that teachers are not aware of. To achieve this, the current study aimed to (1) explore the expectations novice teachers with respect to blended learning have concerning blended learning in general and (2) to compare these with actual experiences of teachers who were asked to teach a flipped classroom. Especially the confirmation of expected challenges can be used to develop support for teachers who are about to transform traditional education into flipped classrooms.

Methods

Two qualitative studies were conducted; one survey study and one interview study. In the survey study, expected opportunities and challenges of blended learning were collected among teachers who were barely, if not at all, acquainted with teaching blended learning courses. In the interview study teachers' first experiences with flipped classroom teaching were gathered.

Survey study exploring teachers' expectations of blended learning
Participants

Participants for the survey study were recruited among voluntary participants of five identical faculty development workshops on blended learning. Participants in these workshops were teachers at Utrecht University in the Netherlands and most often involved in medical education and biomedical science education. The workshops were given in the period October 2013 till June 2014. In total, 148 teachers attended the workshops. Most study participants were inexperienced with blended learning. A minority had some experience with recording lectures, the use of e-modules or digital (formative) assessments.

Setting

Expectations of blended learning were collected after teachers had attended a one and a half hour faculty development workshop on this topic. This preparation was deliberately chosen to ensure that participants understood the concept of blended learning. The workshop started with a general introduction of blended learning, followed by the description published by Garrison: *At its simplest, blended learning is the thoughtful integration of classroom face-to-face learning experiences with online learning experiences*[23]*.* In addition, two examples of blended learning tools were illustrated, i.e. the use of recorded lectures as complementary material to face-to-face education and online formative assessments as a diagnostic tool. Flipped classroom was mentioned as a format to incorporate these tools. The introduction took approximately 20 minutes and was followed by an assignment. Participants, divided into groups of 6-8 teachers, were asked to redesign (parts of) their own course as a blended learning course and discuss the new design with a Strength-Weakness-Opportunities-Threats (SWOT)-analysis. The workshop concluded with a plenary discussion of the course-redesigns and their SWOT-analyses. All educational redesigns consisted of pre-class online learning components, sometimes complemented with digital (formative) assessment.

Method of data collection

After the workshop, participants were invited to fill out a short survey. This survey explored four variables via the following open-ended questions: *"Which opportunities of blended learning do you expect for teachers, and which do you expect for students? Which challenges of blended learning do you expect for teachers, and which ones for students?"*

Analysis

Two educational researchers (RB and RP) individually analyzed all survey data. The answers to each variable were analyzed to deductively define themes and construct a coding scheme. Coding schemes of both researchers were compared and differences in themes were discussed until consensus was reached[24]. This led to a final coding scheme for each of the four variables. Then, both educational researchers independently coded the answers. Inter-rater reliability and Cohen's Kappa were calculated.

Interview study exploring first experiences with flipped classroom teaching

Participants

For the interview study eighteen clinical teachers, who were asked to teach a flipped classroom using blended learning, were invited for semi-structured interviews. None of the participants had attended the workshop on blended learning.

Setting

Flipped classroom based on the blended learning principle was introduced in four knowledge courses of a graduate entry, four-year medical school program at Utrecht University, the Netherlands. The aim of this educational redesign was for students to achieve deeper understanding of the content, due to more interaction and more in-depth discussion with their peers and their teacher in the classroom. Clinical teachers taught the flipped courses.

For each of these courses a teaching assistant was hired for three months to help teachers redesign the pre-class materials, support the recording of weblectures and design student-centered in-class activities. During most classroom meetings, clinical cases were discussed. In others, formative tests alternated with in-depth discussions.

Data collection

After each course teachers were invited to discuss their experience with flipped classroom teaching in a 30-minute semi-structured interview with one of the researchers (RB). Interviews were conducted between April 2014 and April 2015 and all participants gave permission to audiotape the interview for research purposes. In each interview, participants were retrospectively asked to describe their expectations of the concept of flipped classroom, which materials were designed and which in-class activities were planned. In addition, teacher perceptions of in-class activities were discussed and participants could reflect on their first experience of teaching a flipped classroom.

Analysis

A transcriptionist processed the audiotaped interviews verbatim. One researcher identified benefits and challenges in every transcript (RB). All benefits and challenges (either expected, observed or reflected) were coded using the coding schemes that originated from the survey study.
An audit trial was used to ensure analytical rigor[25]. For that purpose an independent educational researcher (RF) checked all steps in the analysis of the interview study. The auditor acknowledged that all steps in the analysis were transparent, logical, valid, and reliable. The auditor report states that all themes were transparent and logical. Comparing subsequent steps in the analyses was easy, since benefits and challenges were chronologically labeled in every transcript and accurately represented in summaries. The transparency was further improved by correcting typographical errors in the verbatim transcripts, as suggested by the auditor. The auditor report is available upon request.

Ethical considerations

All participants were informed about the goals and data handling methods of this study. Responses to the survey and interview transcripts were anonymized for further analyses. This ensured the protection of the privacy and confidentiality of all participants.

Results

Among the 148 participants of the blended learning workshops, 87 volunteered for the survey study. The collected data appeared saturated after 44 respondents. For the interview study, eighteen teachers were invited, eleven of whom volunteered to participate.

Survey theme	*N*	*Description*
Opportunities for students κ= 0.87		
Improved education	40	Improved quality and in-depth education (Effective)
Personalized education	37	Education adapted to individual students, also more fun
Active attitude	31	Students are better prepared and engaged in class
Autonomy	27	Students are better able to decide when, where and how to study
Monitoring	24	Students get insight into their own learning i.e. self-assessment
Time saving (efficiency)	16	Saves students time (efficiency)
Performance	12	Students get better results, both exam scores and knowledge
More motivated	6	Increased motivation among students
Opportunities for teachers κ= 0.80		
In-depth education	25	More opportunity to deepening, or reaching higher levels
Excitatory	17	More fun, more challenging and more interactive education
Time saving (efficiency)	17	Saves teachers time (Efficiency)
Monitoring	14	Teachers have insight into students' progress
Better prepared students	12	Better prepared students have more knowledge when coming to class
Variety in study materials	7	Implement learning resources in multiple courses, more diversity
Effective education	5	Effective teaching results in students achieving higher grades & more knowledge
Accommodate student needs	5	Adapt to students' needs, fits to students preferences
Autonomy	4	Teacher become more autonomous/ flexible

Table 1. Coded and interpreted themes within opportunities and challenges of blended learning as derived from a questionnaire among novice teachers

Survey theme	*N*	*Description*
Challenges for students κ= 0.82		
Limited contact	37	Replacing education with online learning affects face-to-face interaction with peers and / or teacher
Motivation and discipline	32	Students lack motivation or discipline to prepare/ lack the will to change
Distraction	13	Student is provided with too many sources. Consequence: confusion or distraction
Technical problems	11	Students experience technological errors
Quality / alignment	10	Student will learn less if quality and alignment of education is inadequate
Not scholarly	5	Too much structure
Increased workload	4	Amount of work increased, takes students more time to complete (homework)
Challenges for teachers κ= 0.88		
Increased workload	59	Much time is needed to create all materials.
Adapt didactical skills	20	Teacher needs to incorporated didactical skills that are also functional online
Technical issues	17	Teacher needs to learn to work with technique / possible errors
Limited contact	10	Teachers miss out on contact with students, due to replacement by online learning

Continuation Table 1. Coded and interpreted themes within opportunities and challenges of blended learning as derived from a questionnaire among novice teachers. N= number of teachers (surveys) mentioning a theme (N total =87). κ= Cohen's Kappa

Reliability of survey analysis

Preliminary discussion concerning the survey data resulted in a clear description of each theme. Consequentially, large overlap in the coding of answers between the two researchers was found. Cohen's kappa for opportunities for students was 0.87, and for teachers 0.80. Cohen's kappa for challenges for students and teachers were 0.82 and 0.88, respectively.

Expectations of blended learning derived from the survey study

Table 1 shows the themes and their descriptions ranked by frequency.
For students 8 opportunities were deduced and for teachers there were 9. The three most frequently mentioned themes concerning opportunities for students were improved education (n=40), personalized education (n=37) and an active

attitude (n=31). For teachers, the three most frequently expected opportunities were more in-depth (n=25), excitatory (n=17) and efficient (n=17) education.

Challenges for students were coded into 7 themes and challenges for teachers yielded 4 themes. The three most frequently mentioned challenges for students were limited contact (due to replacement of face-to-face education with online learning resources) (n=37), a lack of motivation (n=32) and distraction (n=13). Increased workload (n=59), adaptation of didactical skills (n=20) and technical issues (n=17) were three frequently expected challenges for teachers.

Teacher experience with flipped classrooms

The interview study yielded one new theme concerning challenges for both students and teachers, i.e. limited engagement. Table 2 shows a schematic overview of experiences (as quotes) of teaching a flipped classroom. Quotes are categorized according to the coding scheme originating from teachers expectations of blended learning (Table 1).

Benefits of flipped classroom teaching

Many teachers were enthusiastic about the flipped classroom approach. They liked the interaction with students, although this could be further improved. Teachers became most excited when meetings were interactive and discussions in-depth. Five teachers had the impression that students liked the new teaching approach. Although teachers did not mention the ability to monitor students' online learning, three were able to timely correct misconceptions that became apparent when students discussed clinical cases during face-to-face meetings.
The efficacy of in-depth discussions largely relied on the students' preparation, according to 8 teachers. Six of them noticed that students came to class better prepared than previous cohorts. They described that flipped classroom students were actively discussing clinical cases with peers and that more intelligent questions were asked. Teachers did not identify new benefits for students and teachers.

Themes	*Quotes from teachers*
Benefits for students	
Improved education (8)	I had the impression that my session was less 'frontal' than last year. (Teacher 6) Students asked more sophisticated questions and were discussing the clinical cases. They did not ask to explain terms (Teacher 4).
Personalized education (5)	Students seemed to like sessions with clinical cases (Teacher 7). I had the impression that students liked the formative questions (Teacher 6).
Active attitude (6)	It is possible to deepen students' knowledge, because they attend sessions well prepared. If not adequately prepared, sessions are not useful (Teacher 7). Students were all actively discussing the clinical case (Teacher 9).
Performance (1)	Over the duration of the whole course, students had more readily available knowledge, compared to previous cohorts. (Teacher 4)
Benefits for teachers	
In-depth education (5)	Deepening of knowledge with a real clinical case (a patient) is not possible in a regular lecture (Teacher 10).
Excitatory (7)	I prefer to deepen students' knowledge of a specific topic, rather than to mention the topic briefly. This is more enjoyable (Teacher 4). I became really enthusiastic. It took a lot of time, but it was definitely worth it (Teacher 9).
Monitoring (3)	During discussions with students I noticed that there were many misconceptions to correct and confusions to adjust (Teacher 11). Teachers have to intervene if students explain a topic incorrectly (Teacher 8).
Better prepared students (6)	During the course I noticed that student were better prepared. When I asked questions, answers were provided more readily (Teacher 8). During the whole course student presented with more active knowledge compared to previous years (Teacher 4).
Accommodate to student needs (1)	I think it is wise to prepare just a few slides to review the content, which was discussed in the previous week, let's say the key points. This helps students to organize the course content (Teacher 8).

Table 2. Coded and interpreted themes within benefits and challenges of flipped classroom as derived from interviews among experienced teachers. (n)= number of different teachers mentioning a theme. (N total = 11)

Themes	*Quotes from teachers*
Challenges for students	
Motivation and discipline (7)	Students cannot handle the autonomy [to plan their homework] (Teacher 5). It requires more discipline from the students (Teacher 11).
Distraction (5)	I noticed that students tried to do their homework but still lacked overview (Teacher 9). Students mostly complain that study load is too high and they lack overview (Teacher 11).
Quality / alignment (4)	Part of the group was not prepared and was not able to engage (Teacher 8). Students actually need to do their preparatory homework. That is a prerequisite (Teacher 7).
Increased workload (5)	The amount of (home)work is too much. We continuously expect more from our students (Teacher 1). It is inevitable to increase students' workload if teachers aim for more in-depth understanding. Teachers should be careful (Teacher 4).
Limited engagement (5)	[Instead of answering questions,] students took pictures of the slides, or wrote everything in their notes (Teacher 3).
Challenges for teachers	
Increased workload (9)	I liked the concept of flipped classroom, even though I realized that it would take more time. Other teachers experience a similar increase in workload (Teacher 10). The teaching assistant reduced our workload (Teacher 2).
Adapt didactical skills (4)	I think it was a good decision to briefly recapitulate the content and to highlight key points. This helps the students to develop a correct framework (Teacher 8). Attempting to guide an interactive lecture in a group of students that were inadequately prepared is not useful, I think (Teacher 1).
Technical issues (3)	I had to switch screens and a large part of the students could not engage [vote] because the wireless network was inadequate (Teacher 6). It is a pity if you recorded a lecture and you have to do it all over again (Teacher 9).
Limited engagement (5)	Students were reading, because they had no clue what I was talking about. There was less interaction because students were looking up information (Teacher 2). So the interaction in the classroom was limited, but it was not too disappointing (Teacher 6).

Continuation Table 2.

Challenges of flipped classrooms teaching

Preparing a flipped classroom took more time than teachers had anticipated. Redesigning the in-class activities and the recording of web-lectures were very time consuming. Four teachers claimed that the support of their teaching assistant was essential to achieve their goals. Five teachers estimated that the students' workload had increased as well. They stated that aiming for higher achievement levels (or more in-depth understanding) would obviously be associated with more content being covered.

Teachers learned they had high expectations of their students. Four of them described that a proper preparation by students is a prerequisite for effective flipped classroom education. However, five teachers observed that not all students were able to engage in in-depth discussions and assumed that these students consequentially learned less. (Limited engagement was therefore identified as a new theme.) Teachers provided two explanations why students were not able to engage in these in-depth discussions.
First of all, five teachers had the impression that students were inadequately prepared due to lack of overview. The second explanation, supported by 7 teachers, was the assumption that students could not manage the required preparation. Teachers mentioned three potential causes. They hypothesized that either i) students were not able to manage the expected autonomy or ii) were not motivated enough to complete their homework, or iii) that students considered their homework to be too complex or too much. Teachers felt they had to re-adapt their didactical skills and support students to develop a correct framework of the course content. Starting meetings with a short recapitulation of the preparatory homework was an effective solution to get students to the basic level of understanding.
Besides the increased workload and the perceived limited engagement of students, three teachers experienced technical issues (e.g., switching screens from presentation to online voting software for formative assessment during meetings sometimes failed). Teachers were not aware of students having technical issues during pre-class preparation.

Discussion and conclusion

There was a large similarity between the expectations of blended learning novice teachers and the experiences of the flipped classroom teachers. Time saving for teachers and increased autonomy for students were exceptions to this trend, as the experienced teachers did not mention these. The experienced teachers did address 'limited engagement' as a new challenge affecting both students and teachers. The experienced challenges of flipped classroom could be ascribed to three issues, i.e. workload, engagement and technical issues, which will be discussed in more detail below.

Workload for teachers and students

The fact that the majority of teachers confirmed the most frequently presumed challenge, i.e. increased workload for teachers, is worrisome, especially when one keeps in mind that in the current setting four teaching assistants were hired for three months each to support teachers in the transition from traditional education to flipped classrooms. Despite the published concerns of increased workload[8,9,15] and the precautions that were taken, changing traditional education into a flipped classroom was even more time-consuming than expected. This is in line with the results from Selwood and Pilkington who concluded that implementation of educational change itself is associated with initial time investment. Benefits of these changes, such as reduced workload, are more likely to occur in a later stage[26]. In addition, it might be easier if teachers flipped their course in consecutive steps as suggested by Moffett and Sharma and coworkers[9,10]. This will likely reduce the initial workload for teacher and provides the opportunity for both students and teachers to slowly get used to the new design. On the other hand, inconsistency in the educational design may results in confusion, as students constantly need to adapt their approach to learning.

Teachers estimated that the current design of flipped classrooms resulted in increased workload for students as well. This was no surprise, since the aim of the flipped classrooms was for students to achieve deeper understanding of the content. According to the flipped classroom teachers, this obviously associated with more content to be covered compared to the content needed to achieve a more general understanding, which was aimed for in traditional education.

8

Student engagement

Blended learning-novice teachers' perceived limited contact with students as a major drawback of blended learning. To prevent this, contact hours with students in flipped classrooms were maintained. Nevertheless, the second disadvantage of flipped classrooms was that teachers experienced less interaction with students than expected, defined as limited engagement of students during in-class activities. Teachers assumed that their expectations of students may have been too high, or that limited engagement was due to inadequate preparation of their students.

Teachers expected that this inadequate preparation was either because students could not manage the required preparation, or because they lacked overview. In the future, providing students with even more clear directions and learning goals might help them to prepare in a more effective way. Clear study directions should enable students to distinguish the 'need to know' from the 'nice to know', which is rather difficult for students to do by themselves. One way to achieve this is to reduce the variety of study materials, e.g. by selecting one learning resource out of all the materials, which covers the essential content[18]. Another suggestion is to virtually schedule preparation time into the students' curricular timetables. The visualization of preparatory homework helps students to plan their homework and shows teachers if the required preparation is achievable within the available time.

The flipped classroom teachers also noticed a gap between (online) acquired knowledge and the ability to apply this knowledge in-class. They suggested to start meetings with a small recapitulation of the preparatory homework or to address difficulties students have experienced, based on learning analytics such as the outcome of readiness assessments. When all students have established a basic level of understanding, knowledge can be deepened or expanded.

Technical issues

The third challenge of our flipped classrooms was that teachers faced technical difficulties. These problems were easily solved with non-electronic solutions such as raising hands instead of using online voting systems. Having technical problems is actually not flipped classroom-specific. It could happen to everyone using electronic materials. Masters and Ellaway state that teachers and students should be supported when using any type of e-learning[27].

Strengths

Our study has two strengths. First of all, this paper used data derived from two studies with separate participants. Teacher expectations were gathered in a diverse group of teachers and involved blended learning in general. In the second study we chose one specific form of blended learning and asked teachers with fresh experience of flipped classroom teaching what they observed and experienced. Second of all, in both studies different quality checks were carried out. In the survey study two researchers individually analyzed all data, high reliability values were achieved and saturation in data collection was reached. In the interview study, an independent researcher checked the analyses via an audit trail.

Limitations

Three limitations to the data collection of our two studies need to be addressed. One limitation to the survey study is that we may have encountered a response bias by asking participants of a voluntary workshop to complete our survey. Attendees to voluntary workshops are often people interested in the topic and this might have resulted in more positive expectations than a completely random group of teachers would have. In addition, study participants were likely to address opportunities and challenges that had just been discussed during the workshop, either in the introduction or during the assignment.
The fact that all educational redesigns proposed during the workshops consisted of pre-class online learning components, sometimes complemented with digital (formative) assessment, suggests that teachers were biased due to our workshop. However, this outcome enables us to compare both studies.

The two other limitations concern the interview study.
First, the interviews were scheduled soon after the course was finished. The short interval enabled us to collect teachers' first impressions of teaching a flipped classroom. However, teacher opinions may change after a second or third experience. The changed opinions will be due to teachers getting familiar with flipped classroom teaching. Consequentially, expectations of the flipped classroom, such as interaction and student preparation, may be adapted.
The second limitation to the interview study was that not all themes collected from the survey study were discussed. We deliberately chose open questioning in the interviews, in order for teachers to discuss the most apparent observations and experiences. Due to open questioning we might have missed some of the opportunities or challenges that were expected by novice teachers.
Future research should address the remaining themes from the survey study to determine if these expectations are justified. Themes that should definitively be discussed are workload and time saving for teachers and performance for students such as engagement, exam scores and/or knowledge retention.
In addition, teachers with multiple experiences could reflect on the identified benefits and challenges. Comparison of these more experienced teachers with the findings of the current study could help determine which challenges are caused by educational change in general, and which are flipped classroom-specific. This distinction might be comparable to the study performed by Jensen and coworkers who concluded that the benefits of flipped classroom could be attributed to the active in-class activities rather than to the educational design containing these activities[28].

Conclusion

Expected opportunities and challenges of blended learning largely matched with the experiences of teaching a flipped classroom. Increased workload for students and teachers emerged as an important theme throughout both parts of the study. To successfully implement flipped classrooms, teachers and students need support. Students' preparation was perceived as the bottleneck for successful flipped classrooms. When students were adequately prepared, meetings were more interactive, discussions more in-depth and teachers more enthusiastic.

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Chapter 9

Summarizing discussion

Summarizing discussion

The goal of this thesis was to study the contributions of various technology-enhanced blended learning approaches to effective educational experiences in undergraduate courses. For education to be effective, higher education institutions aim to engage students in meaningful learning, which means stimulating students to actively construct understanding based on acquired facts. To explore if different forms of blended learning contributed this goal, the empirical studies of this thesis will be reviewed from a cognitive perspective by framing their face-to-face and online components in the *Community of Inquiry* framework, as was introduced in the first chapter. This framing enables the findings of individual studies to be discussed in relation to each other, from which overarching conclusions may be drawn.

Framing studies in the Community of Inquiry framework

The Community of Inquiry framework is a pedagogical model that is aimed at engaging students in deep and meaningful learning. It was described that engaging students in learning required the interaction of three domains: cognitive, teaching and social presence[1]. The word *presence* was interpreted as physical occurrence as well as the perception of representation. In the studied technology-enhanced blended learning approaches, cognitive presence regarded the stimulation of students to actively engage in the construction of knowledge[2]. Social presence was interpreted as students' ability to connect and discuss acquired information with peers[3], while teaching presence involved the guidance of this learning process by expanding the constructed knowledge with additional facts and providing students with feedback[4]. Since blended learning approaches consist of a mixture of online and face-to-face education, more flexibility is possible for the three presences to interact, which opens up new opportunities for meaningful and engaging educational experiences[5]. Figure 1 shows that all studies in this thesis at least involve the domain of cognitive presence. Three studies are positioned at the intersection of cognitive and social presence or cognitive and teaching presence and three studies are situated in the center of the model covering all three domains.

Cognitive presence

According to Garrison, cognitive presence involves creative thinking, problem solving and gaining insight[6]. One might imagine that the minimum activity needed for a student to achieve this, is to be in contact with the content of a course. In line with this thought, Bell and coworkers suggested that actively re-processing content is sufficient to reduce loss of knowledge[7]. The study in chapter 4 examined whether repeatedly taking a test on the same content and without additional study effort was enough to better retain knowledge. The findings did show that both intervention and control group students lost a substantial amount of knowledge (up to 1/3 might be expected after 1 year[8]), but a better retention for students in the intervention group could not be demonstrated. When considering the Community of Inquiry framework, this intervention involved cognitive presence only. Social presence and teaching presence were absent, since standard test conditions were applied. In these conditions students are not allowed to discuss with peers, and teachers are not providing feedback or instruction. Unfortunately, the findings of this study remain inconclusive, because of low experimental power. Based on this study, it remains uncertain if cognitive presence alone is enough to *maintain* (more) knowledge. The effectiveness of sole cognitive presence in relation to *learning new* content was not explicitly studied in this thesis, although students' preparation for classroom meetings might fulfill this criterion. To explore if social presence has an additional impact on cognitive presence, Gokhale and coworkers performed a comparative study. They described that studying individually or in collaboration with peers is equally effective in enhancing the ability to recall basic facts[9]. However, critical thinking and problem solving skills are better developed during collaborative learning[9,10]. Perhaps similar outcomes might be expected when cognitive presence is combined with teaching presence, for example in formative testing.

Still, the added value of technology-enhanced learning in knowledge acquisition (cognitive presence) is debatable[11]. The introduction described that incorporation of e-learning might stimulate student engagement because blended learning resembles students day-to-day activities[12,13]. Students frequently use online platforms, not only to find information but also to interact with peers and friends. For example, college students at Baylor University reported to use smartphones up to ten hours per day[11]. Although the purpose of use was not specified, this trend might suggest that technology-enhanced education can be a fruitful contributor to learning. Still, it is undetermined if all students are digitally literate, meaning that every student is able to effectively use electronics to find and learn new content, and therefore if introduction of technology-enhanced education is the best way to support students individual learning when only cognitive presence is sensed.

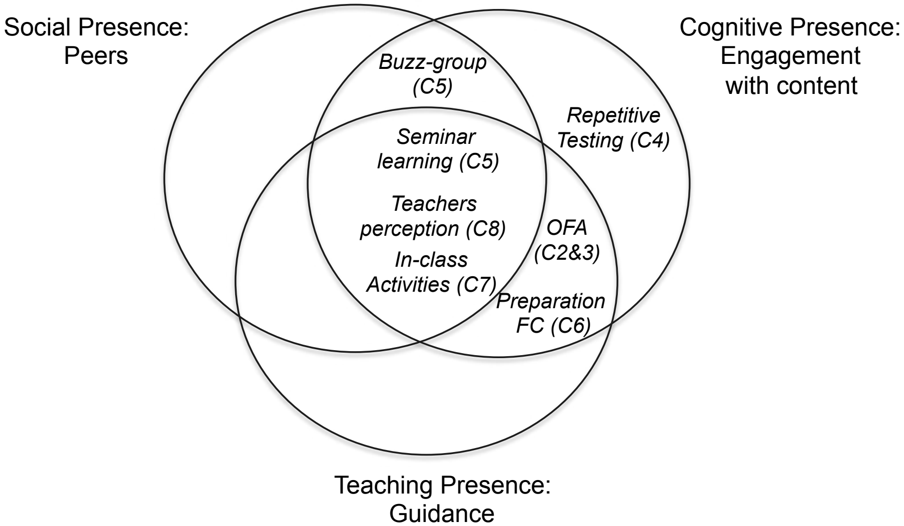

Figure 1. Framing blended learning tools and educational approaches in Community of Inquiry framework. OFA = Online Formative Assessment, FC = Flipped Classroom, Cn = number of chapter in thesis.

Cognitive presence interacting with social presence

The interaction of cognitive presence and social presence involves group cohesion with peers and discussion regarding content[2]. The buzz groups studied in chapter 5 were positioned at this intersection of cognitive and social presence (Figure 1). In buzz groups, a form of small group learning, students are expected to constructively discuss content and to ask and respond to questions of peers[14]. In the study concerning seminar learning, a new format was introduced that focused on peer-instruction and peer-driven plenary discussion. The findings of this study show that the main advantage of the new format was that students were better prepared compared to previous cohorts and that students participated more actively during group discussions. This active discussion led students to believe that they were better able to present the correct answer later in the plenary discussion, and that active discussion with peers helped students to better understand the content. In addition, statistical analysis showed that preparation of peers contributed to confidence in finding the correct answer and deepening of knowledge. We also expected that another dimension of social presence, peer-pressure, would stimulate students to prepare themselves better for subsequent seminars. The average self-reported preparation time did not indicate that students (felt the need to) invest more time preparing the assignments, since self-reported preparation time was approximately the same for all seminars. This finding might also explain

why students' preparation time did not associate with the deepening of knowledge and confidence in finding the correct answer. The outcomes thus illustrate that social presence positively contributes to an effective learning experience.
In chapter 5, social presence was supported in face-to-face meetings, but social presence can also be achieved in online learning. Examples of effective forms of social presence in online learning are group contributions to writing an essay or report or the participation in an online debate[15]. In these examples social presence is achieved through discussing different perspectives and providing and receiving feedback resulting in group consensus and social construction of knowledge[16]. An advantage of online collaboration, as compared to face-to-face collaboration, is that individual participation is relatively easy to distinguish from the group, when instructors examine the written records[15].

Cognitive presence interacting with teaching presence
The interaction of cognitive presence and teaching presence involves creation of course materials, facilitating discourse and providing feedback[4]. In this thesis, two studies were located at the intersection of cognitive presence and teaching presence. One study involved teacher guidance on students' learning process in the form of online feedback that students received in response to answering (formative) questions. Feedback in formative assessment was focused on in chapters 2 and 3 and was associated with increased student performance on summative examination. This finding is in line with other studies focusing on formative assessment[17-19]. In the intervention described in Chapter 2, students were provided both with written feedback, explaining the most likely mistake leading to one of the alternative answers, and with a direct link to a small fragment of the live lecture. In both cases, students could learn from their mistakes, and were directed towards and provided with the correct answer after three attempts. In this study, student learning was supported irrespective of students' personal learning preferences, because written feedback and video feedback were presented at the same time. However, it remains unclear which form of feedback was actually used or perceived to be most useful. In a recent publication, Morris and Chikwa studied learners' preferences for audio and written feedback. Their findings show that students had a strong preference for written comments, but the type of feedback did not influence student performance[20].

In addition to the quantitative findings that formative assessments improve exam scores, student motivation to use or to not use formative assessments was studied to unravel the underlying mechanism. The findings in chapter 3 show that students used the formative assessments to gain insight into the summative exam, to determine what needs to be studied and how students' current performance relates to the expected level of the summative exam. This feed up, feed forward, and feed back might be interpreted as examples of teaching presence in formative assessments. The interaction of cognitive presence with teaching presence may be the underlying cause for improved performance on summative exams.

Providing feedback is just one example of teaching presence. Other forms of teaching presence involve creating and selecting content, directing students to learning resources, stimulating students to participate, and sharing knowledge[4]. The latter forms of teaching presence often occur in the classroom, whereas creating and selecting content also affects homework activities. Active engagement in homework activities is important, especially in preparation for flipped classrooms. In chapter 6, students' preferential use of a diversity of online learning materials to prepare for knowledge application in flipped classrooms was studied.
In two different courses students chose to prepare themselves mostly by watching weblectures and reading selected text fragments. Next to that, students used formative assessments and case studies to collect feedback. By applying knowledge retrieved from weblectures and text to formative assessments or clinical case studies, students could determine if they were ready for in-class activities and deepening of knowledge. This is in line with Rusthon's and Barrows' reports who described the advantages of formative assessment and clinical cases respectively[21,22]. In addition, students were offered alternative books and scientific papers. With these materials students could expand or deepen their current knowledge by themselves. In practice, students used these materials less intensively and no correlations were found between the use of pre-class study materials and deep learning strategies. In chapter 6, it was discussed that cognitive overload or limited study time may explain the limited use of these challenging materials. However, in light of the Community of Inquiry framework, an alternative explanation might be that teaching presence was less visible in alternative books and scientific papers. Compared to weblectures and text fragments, that are often created or selected by teachers themselves, alternative books and scientific papers may be perceived as more detached. In other words, students may only perceive cognitive presence in additional materials, which may have not satisfied students learning needs. One of these needs might be insight into the hidden curriculum. The hidden curriculum is described as '*the set of influences at the level of organizational structure and culture including implicit aspects*'[23]. For example, the hidden curriculum in undergraduate courses could provide students with

insight into topics or subjects that teachers find most important. These subjects are likely to be tested in the summative exam. Overall, students' preferential use of study material supports the notion that the combination of cognitive and teaching presence is valuable to learn (new) content.

In summary, the findings lead us to assume that cognitive presence combined with social presence or combined with teaching presence improves students' ability to actively construct knowledge. The proxy measure for improved construction of knowledge in our studies was the increase in exam scores. Both feedback from teachers (chapter 2 and 6) and discussion with peers (chapter 5) resulted in increased scores on summative exams.

Interaction of cognitive, social and teaching presence

The Community of Inquiry framework states that the interaction of cognitive, social and teaching presence contributes to deep and meaningful learning experiences[1]. So far, studies in this thesis seem to confirm that combining cognitive presence with a second domain is beneficial for learning. However, it remains to be explored if studies in which all three domains of Community of Inquiry are present may result in more convincing findings compared to the studies discussed previously. In this thesis, two interventions were positioned in the center of the Community of Inquiry framework; seminar learning (Chapter 5) and flipped classrooms (Chapters 7 & 8). In both interventions, students were required to prepare for in-class activities. In seminars, cognitive presence was affirmed by preparing assignments, whereas in flipped classrooms new knowledge must be comprehended before class. In both approaches active discussion with peers (social presence) was intended to result in better understanding of the content, and teachers were guiding these in-class activities (teaching presence).

As described previously, deepening of knowledge and confidence in finding the correct answers to seminar assignments related to the perceived preparation of peers (Chapter 5). Comparing and discussing with peers (i.e. social presence) and applying knowledge to pathology cases (i.e. cognitive presence) were two highly rated supplementary explanations of students when asked why attending seminars was perceived useful. Still, students worried whether they had found the correct answer, even after discussion with peers. Students specifically asked for teachers to confirm if the answer to seminar assignments were correct and complete. The perceived importance of teacher confirmation is supported by the work of Ellis showing that confirmation by a teacher positively influenced students' motivation and affective learning via reduced student apprehension[24]. Therefore, these findings illustrate that in addition to cognitive and social presence, also teaching presence for students played an important role.

Behavior in flipped classrooms was analyzed by measuring type and duration of teacher and student interactions. Chapter 7 describes that interaction dynamics in flipped classrooms are improved compared to traditional classrooms. Teachers challenged their students to interact more by frequently asking questions and by praising students and correcting answers. The latter two were used as proxy measures for providing feedback[25]. This emphasized teaching presence resulted in increased student activity. For example, a significant increase was measured for students' responding to questions, a measure for cognitive presence. Social presence was most abundantly observed in flipped classroom using buzz groups, however these interactive classrooms could not be included in the analysis due to methodological limitations.
Although direct data are thus lacking in this thesis, some teachers did report that flipping the classroom enhanced student engagement in face-to-face meetings. In Chapter 8, it is found that teachers were enthusiastic about flipped classrooms because face-to-face sessions were interactive and classroom discussions were more in-depth compared to previous cohorts using traditional forms of education. In addition, teachers in flipped classrooms claimed to be better able to correct misconceptions during peer discussion.
These summarized opinions indicate that teachers do perceive that the interaction of all three Community of Inquiry domains can result in engaging and perhaps more effective learning experiences. However, teachers also acknowledged that achieving effective flipped classrooms required more time and effort than they had anticipated. From their first experience of teaching a flipped classroom, it seemed that students' (inadequate) preparation was the bottleneck for successful flipped classrooms.

In summary, the perception of students and teachers indicate that the interaction of all three domains of Community of Inquiry can contribute to meaningful and deep learning, at least in active forms of student-centered education. In case of seminar learning, cognitive and social presence were established and teaching presence was declared to be beneficial. Whereas in case of flipped classrooms, cognitive and teaching presence were ascertained and social presence was perceived to enhance deep and meaningful learning of students.
The studies in this thesis aimed to stimulate meaningful learning by introducing

technology-enhanced education. Overall, studies were performed within the cognitive domain of the Community of Inquiry framework and in most of these studies the interaction with social and / or teaching presence was established (Figure 1). Student behavior and opinions suggests that the combination of cognitive presence and teaching presence seems to be most powerful, but the interaction with social presence seems to facilitate students' (preparation and) active participation. This is in line with the finding of Shea and Bidjerano's work who explored the causal relationships between the three presences of Community of Inquiry[26]. Their conclusion confirmed earlier work of Garrison that stated that social presence is a mediating factor between cognitive and teaching presence[2]. In addition, a reflection on a decade of research devoted to the Community of Inquiry concluded that social presence and cognitive presence were causally influenced by teaching presence[27].

Practical restrictions to the experiments

Most limitations discussed in individual chapters are linked to the fact that interventions were studied within the context of an existing educational curriculum. These studies were thereby assessed using objectives-oriented and participant-oriented evaluations. Objectives-oriented evaluation concerns enrollment of participants, completion numbers and learning outcomes, whereas participant-oriented evaluation involves the perception of participants[28]. Frequently encountered challenges in the studies regarded selection bias, research design but also some technological limitations were experienced.

Selection bias

The blended learning interventions in this thesis were all studied in the context of medical or biomedical courses. The advantage is that the intervention was directly tested in a realistic and purposeful environment. The downside is that the studies were dealing with convenience samples and that in some studies participants chose to quit the experiment. Using a convenience sample is actually a threat to external validity, since the study participants are not necessarily representative for the whole population[29,30]. Consequentially, conclusions were drawn based upon the performance and perception of volunteering students, who are often highly motivated and well-performing students[31]. When analyzing quantitative results, for instance exam scores, a correction based on averaged previous performance was used to minimize the effect of this confounder.

Generalizability problems might also be encountered due to voluntary participation of some teachers. Unless a dean obligates his or her teachers to implement educational innovations, these are more likely to be introduced by teachers who have a positive perception of the benefits the innovation may create. This generalizability problem was most probable in biomedical course, since flipped classrooms were mostly implemented upon request of the program director.

In his book '*Visible learning*' Hattie summarized over 800 meta-analyses related to achievement[32]. Hattie reports that when educators only critically think about their education student satisfaction is positively affected. In case of blended learning, interventions are often implemented by academic staff with skills and confidence in using technology-enhanced and online forms of education. In practice this number of digitally fluent faculty remains low[33,34]. Taking faculty development workshops on technology-enhanced education and online learning can help these teachers to develop blended learning skills.

Research design

In contrast to the studies in biomedical courses, dealing with cohorts of approximately 150 students, studies regarding flipped classrooms were restricted to medical courses with a maximum of 40 students, which limits the power of study outcomes. This problem is most apparent when the study is intended to explore differences. Preferably, 50% of the participants would be assigned to a control group. However, when exploring the effects of innovations within an existing educational curriculum this approach is problematic. Ethical considerations do not allow investigators to withhold information or resources from a subgroup of participants as this may lead to an unequal advantage to the students in the control or intervention group. A solution could for example be a comparative study in which multiple courses or two subsequent cohorts are included.

In this thesis, performing correlational studies circumvented the problem with small groups. However, it is difficult to conclude what the added value of the intervention is, compared to the situation without the intervention. Moreover, developmental and teacher effects may already lead to some effect sizes[32].

In other studies, such as the study concerning online formative assessments, experimental condition were controlled better, since one part of the students chose to use the tool, while the other part did not. The problem remains that it is unclear what the consequences of the intervention would have been, when the students would have decided otherwise, or were assigned to a control or intervention group. In the same context, Cook and coworkers used a randomized, controlled, crossover design to investigate the effect of formative assessments showing that formative assessments indeed lead to enhanced learning outcomes[35].

Technical limitations

Besides the curriculum related issues, some technological restrictions were encountered as well. For example, the program used for online formative assessment recorded one score per formative assessment per student. This allowed the researcher to either save students' first attempt or students' best performance per formative assessment. Due to this technological limitation, it remains unknown how many attempts were done in total, how much time students spent on this task, or if the student looked at the feedback (the written text or the video fragment). A comparable problem was experienced with the use of iBooks in one of the flipped classroom studies. In this study researchers had no insight in to the actual use of online learning materials. Solving these technical limitations will provide a clear advantage of online (or blended) learning compared to traditional education. Being able to gain insight into these tracking data will show both researchers and teachers which materials are used when and for how long and how many times in total. In this case, asking students to indicate the use of materials on a frequent basis and to share personal perception of the different study variables circumvented this problem. Self-reported use of materials or perception are considered appropriate measure and are often collected in combination with exam scores or other learning outcomes[36].

Opportunities for future research

The empirical studies described in this thesis provide insight into some possibilities that blended learning tools and approaches can achieve in relation to the experience of effective education, however much is left to be investigated. Suggestions for future research are divided into studies that directly follow-up on individual chapters, studies that extent the framing of technology-enhanced education into the Community of Inquiry framework, and studies focusing on other potential opportunities of technology-enhanced learning.

Direct follow-up on individual chapters

The insights in this thesis are mainly focused on short-term goals like improved performance at midterm or end-of-course exams. What is still unclear is whether blended learning tools and / or approaches are valuable when focusing on retention of acquired knowledge. The pilot study, in chapter 4, shows one intervention aiming to optimize retention, but unfortunately the findings were inconclusive. It was discussed that repeated examination only served students' cognitive presence, which, according to the Community of Inquiry framework, is presumably not sufficient to retain more knowledge. Maybe if students were allowed to discuss items during the intervention exams (adding social presence) or if students were provided with feedback concerning correct and incorrect answers (teaching presence) might help students, and making repetitive testing a useful contributor to students' ability to remember course content.

A better retention of knowledge was also expected from the flipped classroom approach[37]. It is suggested that actively processing the studied material in class, helps students to better understand the content[12]. Until now, it is not known whether flipping the classroom is beneficial for retention of knowledge and what kind of information (facts or deeper understanding) is retained best. Teachers experiencing flipped classroom perceived that social presence (discussion with peers) to the interaction of cognitive and teaching presence would contribute to a more meaningful learning experience in-class. Examining students long-term knowledge, for instance one year after the end-of-course exam, will show if flipping the classroom improves student retention of knowledge. When the exam is composed of both low-level cognitive questions (repetition of facts) and cognitively more complex questions (solving problems), researchers will be able to determine what type of knowledge retains best after a flipped classroom approach. Preliminary results of Colbert-Getz and coworkers suggest that an increase in cognitively more complex questions might be expected, although the retention interval was not mentioned[38].

Besides studying knowledge retention, it is also interesting to find out what caused this expected improvement. One of the underlying mechanisms of increased knowledge (and retention) is that students are expected to actively process the acquired knowledge in the classroom. This active processing involves higher-order thinking activities, such as critical thinking and elaboration[39,40]. To the best of our knowledge, literature is lacking evidence that flipped classroom sessions achieved these cognitively complex, higher-order thinking activities. Future research could observe or survey students' perception of deepening of knowledge in flipped classrooms, and a properly aligned higher-order exam could be used to confirm that students have achieved this higher-level thinking.

Extending the framing of technology-enhanced education studies in the Community of Inquiry framework

When looking at the framing of the studies in the Community of Inquiry framework, it appears that (obviously) much attention was paid to cognitive presence (Figure

1). However, teaching presence was also largely represented in the studies. In some cases teaching presence involved feedback on student learning and performance, in other studies teaching presence involved creation and organization of course materials. In contrast to cognitive and teaching presence, social presence seems somewhat overlooked. It is suggested that future studies could focus more on the role of peers in meaningful learning. Two examples will be described below.
First, when students are asked to work together, this often is to complete written assignments or during face-to-face activities. The advantage of collaboration with peers could however be extended to online learning and to other elements of a course. Two suggestions are collaborative acquisition of knowledge when preparing for flipped classrooms and collaborative exam preparation. The potential benefits of shared knowledge construction and supporting discourse could result in a meaningful learning experience and an improved understanding of the content.
Second, as described in the introduction, peers are suitable partners to communicate with since they presumably share identical learning goals. Having the same goal and actively processing the same content can contribute to a sense of group cohesion, or relatedness.

Studies focusing on the potential opportunities of technology-enhanced learning

As described earlier, the advantage of online learning is that student performance and activities can be tracked. When these learning records are stored for large groups of students and over a long period of time, it might be possible to identify patterns in student learning. These patterns are the result of learning analytics and are a relevant contribution to educational research as well educational practice[11,41].
From a scientific point of view, learning analytics could provide researchers with a tool to better understand how (groups of) students are learning, but also gain insight into the diversity in student approaches and strategies to learning.
From a practical point of view, data originating from learning analytics can be used to compare the performance and progress of an individual student to classmates or peers in previous cohorts. This comparison could identify students who could be challenged more, in order to achieve higher learning goals or identify if the progress of a student is slowed needing attention. On the other hand, using learning analytics could also identify misconceptions on student or group level, which can be corrected during the teaching and learning process of the course. As such, learning analytics could help teachers developing specific and personalized learning opportunities for students[34,42].

Implications for educational practice

The findings of the studies presented in this thesis have resulted in implication for educational practice. These implications could help educators to effectively redesign a course into an active student-centered course using technology-enhanced tools or approaches. The implications are arranged in chronological order of a course.

Pre-class preparation

As illustrated in Figure 2, pre-class preparation was studied in three chapters. In these studies a combination of cognitive and teaching presence was observed. Pre-class preparation did not involve social presence, since students mostly prepared themselves individually. In flipped classrooms students were expected to gather new knowledge during homework activities. Whereas, in other student-centered forms of (traditional) education, new information is often shared in lectures, but students need to process the information before active application in this case in seminar learning.

Based on students preferential use of study materials, discussed in **chapter 6**, and students motivation to prepare for seminar learning, described in **chapter 5**, it is advised to provide students with preparatory homework activities that are manageable and at a lower cognitive complexity. Examples of such homework activities are watching an online weblecture or reading selected text fragments. If preparatory homework is too complex, students can become demotivated and are more likely to quit. In contrast, students' motivation to prepare was improved when students' acquired knowledge was used during face-to-face sessions. In case of seminar learning students described to be more motivated to prepare, because then they were able to discuss their own answers to answers given by peers. In addition, based on the studies concerning flipped classrooms, for example **chapter 8**, it is advised to explain to students what is expected of them and what activities will be performed during face-to-face sessions. In the flipped classroom courses, the goals and activities were explained to students before the first lecture. As a consequence, teachers perceived that students were better prepared compared to previous cohorts and students in flipped classrooms had more readily available knowledge during the whole course. The implications are summarized in Figure 3.

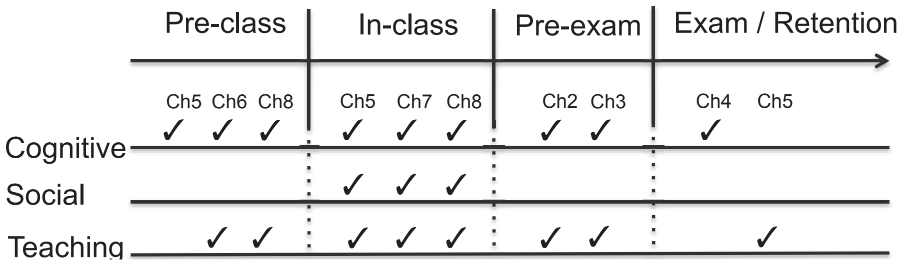

Figure 2. Arrangement of chapters according to the focus area in a course. Existence of cognitive, social and teaching presence in each chapter are indicated with 'v'.

In-class activities

Three studies in this thesis explored students' and teachers' in-class activities and Figure 2 indicates that cognitive, social and teaching presence was observed in these studies (**chapters 5, 7 and 8**). The aim of the classroom sessions was to enhance active engagement and achieve meaningful learning. In seminar learning and flipped classrooms, students were actively discussing assignments or clinical cases with peers. The teacher was available to direct student learning, for instance answers questions that peers were not able to answer, to correct misconceptions and to confirm that solutions to the assignments were correct. To achieve active engagement and meaningful learning it is advised to build up on the knowledge that students have acquired during homework activities (Figure 3). This elaboration of knowledge could for example be achieved via interaction with peers or via interaction with the teacher. As shown in **chapter 7**, asking questions to students will encourage them to actively participate and to engage in learning activities. Consequentially, flipped classroom teachers perceived that classroom discussions were more in-depth (**Chapter 8**). In line with these findings, **chapter 5** described that attendance to interactive classroom sessions was associated with increased performance on summative exam.

Exam preparation

Students' exam preparation was studied using one intervention, i.e. online formative assessments (**Chapters 2 and 3**). Online formative assessments helped student to gain insight in to the exam, determine what needs to be studied and shows them how their current performance relates the level of the summative exam. In these feed-forward and feedback elements of formative testing both cognitive and teaching presence were assumed to be present (Figure 2). Since the formative assessments provide students with study direction to improve their

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performance, it is advised to invest in generating specific and detailed feedback (Figure 3). For instance, explaining the most likely mistake leading to each alternative answer.

Goal, examination and retention

The final goal for students is often to pass the summative exam with the best possible marks. It is thereby important to align homework activities and in-class activities to the requirements of the summative exam (Figure 3). One approach to achieve cognitive alignment between educational activities and summative exams was briefly described in **chapter 5**. In this relatively easy approach two educational researchers individually examined the cognitive complexity of seminar assignments and exam items using a coding scheme. This coding scheme helped them to discuss the differences and to achieve consensus on the complexity of individual assignments and exam items.

Educational goals for teachers are often more pedagogical, for example to achieve deep and meaningful learning. The studies in this thesis may contribute to the suggestion that deep and meaningful learning is best achieved when teachers and educational designers consider all three domains of the Community of Inquiry framework in their course redesign.

With respect to the retention of knowledge, this thesis includes one pilot study. In this study students might only have experienced cognitive presence (see Figure 2), since standard test conditions were used. Unfortunately, it remains inconclusive whether repetitive examination without additional study effort is sufficient to reduce knowledge decay. Nevertheless, the necessity to improve knowledge retention is evident[12,37].

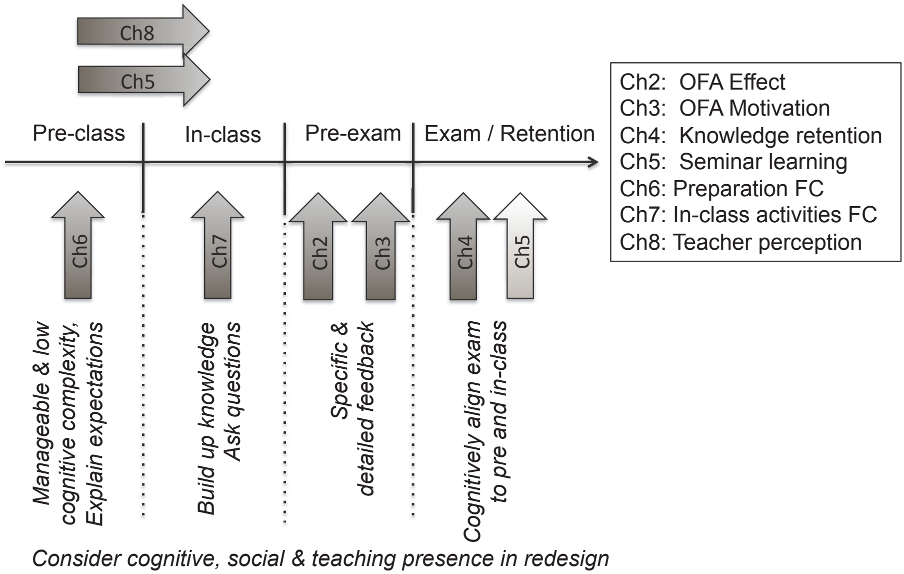

Figure 3. Implications for educational practice.

Implications are shown italic; arrows indicate the chapter with supporting evidence

Final considerations

The goal of this thesis was to study different blended learning approaches to determine if technology-enhanced education could stimulate student engagement and meaningful learning in courses. Different parts of a course have been studied in different interventions. The use of online materials was discussed in order to prepare for in-class learning activities and summative exams, student-centered interventions were implemented to enhance engagement in classrooms, and a pilot experiment was intended at improving retention of knowledge. In hindsight, the Community of Inquiry framework appeared to be a useful model to better understand why some experiments were more successful, and how other interventions might be improved.

It can be concluded that effective and meaningful technology-enhanced learning was experienced when students perceived the existence of cognitive presence in combination with teaching presence, both in online and in face-to-face education. Social presence, a sense of relatedness and the ability to discuss with peers, seemed to facilitate students' active participation.

9

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Appendices

Summary in Dutch

Nederlandse samenvatting

Universitair (bio)medisch onderwijs is er op gericht om academici van de toekomst op te leiden die in staat zijn een bijdrage te leveren aan toekomstige ontwikkelingen in wetenschap, geneeskunde of maatschappij. Om dit te bereiken vergen de opleidingen van studenten dat zij niet alleen het *kennis verwerven*, maar juist ook constructief *kennis toepassen* om complexe vraagstukken op te lossen. Het opleidingsprogramma bestaat uit een reeks cursussen die dusdanig zijn ingericht dat alle kennis en toepassing hiervan uiteindelijk leiden tot het eerder genoemde doel. De studenten zijn zich echter niet altijd bewust van dit hogere einddoel, waardoor de focus vaak ligt op het halen van individuele cursussen met een zo hoog mogelijk cijfer. Hierbij komt de nadruk vaker te liggen op het verkrijgen van kennis dan op het toepassen van kennis. Het ontwerp van cursussen die ook leiden tot het toepassen van kennis staan in dit proefschrift centraal. In deze context is met name onderzocht of de inzet van onderwijstechnologie in combinatie met klassikaal onderwijs een effectieve onderwijsvorm kan zijn.

In **hoofdstuk 1** wordt uitgelegd dat het toepassen van kennis en kritisch denken beter geleerd wordt wanneer de student centraal staat in het onderwijs. Dit houdt in dat het toelichten van dia's in grote collegezalen door een docent wellicht beter vervangen kan worden door wat kleinschaliger onderwijs waarbij vooral de student actief met de stof bezig is, bijvoorbeeld door het discussiëren met studiegenoten. Een docent speelt hierbij nog steeds een belangrijke rol, omdat de docent richting kan geven aan de gedachten van de student bijvoorbeeld door het geven van feedback. Het actief bezig zijn met de *inhoud*, het *bediscussiëren* met studiegenoten en de *sturing* van de docent zijn drie belangrijke elementen die centraal staan in het onderwijskundige '*Community of Inquiry*' model. Volgens dit model zorgt de onderlinge interactie tussen inhoud, discussie en begeleiding voor een effectieve en betekenisvolle leerervaring. Naast actieve betrokkenheid van de student wordt een effectieve en betekenisvolle leerervaring ook bevorderd wanneer het onderwijs aantrekkelijk is. Een manier om onderwijs aantrekkelijker te laten zijn voor studenten is door het meer te doen lijken op dagelijkse activiteiten, bijvoorbeeld door het inzetten van digitaal leermateriaal (onderwijstechnologie).
Het mixen van digitaal en traditioneel onderwijs wordt ook wel *blended learning* genoemd. Blended learning heeft vele verschijningsvormen. Soms wordt alleen gebruik gemaakt van een klein stukje digitaal materiaal, terwijl andere docenten de gehele onderwijsaanpak veranderen, bijvoorbeeld door het invoeren van zogeheten *Flipped classrooms*. Bij een flipped classroom worden klassikale en huiswerk activiteiten van plaats verwisseld. In de traditionele vorm maakt de student thuis opdrachten om vervolgens naar het contactonderwijs te komen voor verdere kennisverwerving en uitleg. In een flipped classroom bereidt de student zich thuis voor door eerst kennis te verwerven, bijvoorbeeld door naar een opname van een hoorcollege te kijken. Vervolgens komt de student naar het contactonderwijs waar, onder begeleiding van de docent, de opgedane kennis wordt toegepast in de vorm van opdrachten. In het afgelopen decennium is het aandeel en de populariteit

van onderwijstechnologie sterk toegenomen. Het doel van dit proefschrift is te onderzoeken of verschillende vormen van onderwijstechnologie kunnen bijdragen aan student betrokkenheid en effectief en betekenisvol studeren.
Om dat te doen zijn verschillende studies uitgevoerd die zich gericht hebben op de voorbereiding van studenten op het contactonderwijs en de toets, de activiteiten tijdens een contactonderwijs en het behoud van kennis na afloop van een cursus. Daarnaast is de perceptie van docenten ten aanzien van onderwijstechnologie in kaart gebracht. De eerste drie studies zijn daarbij meer gericht op de inzet van een klein stukje onderwijstechnologie, waar in de laatste hoofdstukken de gehele onderwijsaanpak werd veranderd.

In **hoofdstuk 2** werd de effectiviteit van formatieve toetsen, ook wel zelftoetsen genaamd, onderzocht in relatie tot cijfers op de eindtoets. In tegenstelling tot summatieve toetsen die tot doel hebben de student te beoordelen na het studeren, geven formatieve toetsen juist feedback aan studenten tijdens het studeren. In de formatieve toetsen die onderzocht werden in dit hoofdstuk, werd het juiste antwoord van studenten bevestigd, of werd extra uitleg gegeven wanneer het gekozen antwoord onjuist was. Deze extra uitleg bestond uit een toelichting over de meest waarschijnlijke foutieve denkstap die leidde tot het gekozen antwoord. Na drie pogingen werd het juiste antwoord weergegeven en kreeg de student ook algemene feedback over het juiste antwoord. Naast de geschreven feedback kregen de studenten ook een link naar een relevant fragment uit het opgenomen hoorcollege. Voor alle drie de hoofdonderwerpen uit de cursus was een zelftoets gemaakt.
De studenten die gebruik maakten van de formatieve toetsen scoorden gemiddeld één punt hoger op de multiple choice tussentoetsen. Deze verbetering stond los van hun prestaties uit eerdere cursussen. De cijfers op de eindtoets, bestaande uit open vragen, waren niet significant hoger dan die van groepsgenoten die geen formatieve toetsen hadden gebruikt. De resultaten uit deze studie suggereren dus dat formatieve toetsen die studenten voorzien van geschreven feedback en een link naar een fragment uit het hoorcollege kunnen bijdragen aan een hoger toetscijfer, mits de toetsen goed op elkaar zijn afgestemd.

Om inzicht te krijgen in waarom studenten wel of juist geen gebruik maken van boven beschreven formatieve toetsen, is in **hoofdstuk 3** onderzoek gedaan naar de motivatie van beide groepen studenten. Het gebruik van formatieve toetsen werd automatisch geregistreerd in de online leeromgeving. Na afloop van de 2e tussentoets werd studenten gevraagd toe te lichten waarom zij er voor gekozen hadden om wel of geen gebruik te maken van de formatieve toetsen. Op basis van de open antwoorden werd een tweede vragenlijst opgesteld met gesloten vragen, die na afloop van de derde tussentoets kon worden ingevuld. Studenten konden hierin aangeven in hoeverre argumenten voor het wel of niet gebruiken van formatieve toetsen voor hen van toepassing waren.
De analyse van antwoorden op deze tweede vragenlijst toonde aan dat de motivatie voor het gebruiken van zelftoetsen uit drie redenen bestaat, die zijn

gelabeld als *feed up*, *feed forward* en *feed back*. Feed up informatie geeft studenten inzicht in het doel, bijvoorbeeld in de vorm en inhoud van de summatieve toets. Feed forward informatie geeft studenten inzicht in wat zij nog beter moeten leren en welke onderdelen zij nog onvoldoende beheersen. De derde reden voor het gebruiken van formatieve toetsen was het verkrijgen van feedback. Met feedback informatie wordt bedoeld dat de student inzicht krijgt in zijn of haar eigen kunnen ten opzichte van het doel, in dit geval de summatieve toets. Uit de antwoorden konden redenen voor het niet gebruiken van formatieve toetsen helaas niet worden gedestilleerd.

Omdat het kennisniveau na afloop van de summatieve eindtoets vaak snel vervalt, is een pilotstudie uitgevoerd waarin werd onderzocht of het herhaald afnemen van een toets kan bijdragen aan het beter behouden van kennis. In **hoofdstuk 4**, is beschreven dat studenten werden uitgenodigd om op 3 momenten na een summatieve eindtoets terug te komen om nogmaals een toets te maken, maar zonder daarvoor te studeren. De cijfers van de uiteindelijke retentietoets werden vervolgens vergeleken met de cijfers van studenten in de controle groep. Uit de resultaten blijkt dat het kennisniveau van beide groepen na 7 maanden duidelijk lager is dan tijdens de summatieve toets. Echter kon geen verschil worden aangetoond tussen beide groepen, vermoedelijk vanwege het kleine aantal studenten dat de volledige interventie en de eindmeting had afgerond.

Hoofdstuk 5 richtte zich op het activeren van studenten in kleinschalig werkgroeponderwijs. Om goede voorbereiding en actieve deelname aan de werkgroepen te bevorderen, werd de onderwijsvorm aangepast. In de nieuwe vorm werd het contactonderwijs ingedeeld in twee onderdelen. Eerst konden studenten de antwoorden op thuis voorbereide werkgroepopdrachten bespreken in zogenoemde buzz-groepjes van 5 studenten. Vervolgens moest ieder van de 6 buzz-groepen het antwoord op een van deze opdrachten plenair toelichten. Er werd verondersteld dat studenten (binnen buzz-groepjes) elkaar zouden stimuleren om goed voorbereid te zijn en actief deel te nemen.
Via vragenlijsten werd onderzocht hoe studenten zich voorbereidden en werd uitgevraagd in hoeverre deelname aan de werkgroep had bijgedragen aan het leren. De resultaten uit dit hoofdstuk laten zien dat de voorbereiding van groepsgenoten bijdraagt aan de ervaren kwaliteit van de werkgroep en dat deelname aan deze werkgroepen samenhangt met een hoger cijfer op de eindtoets.

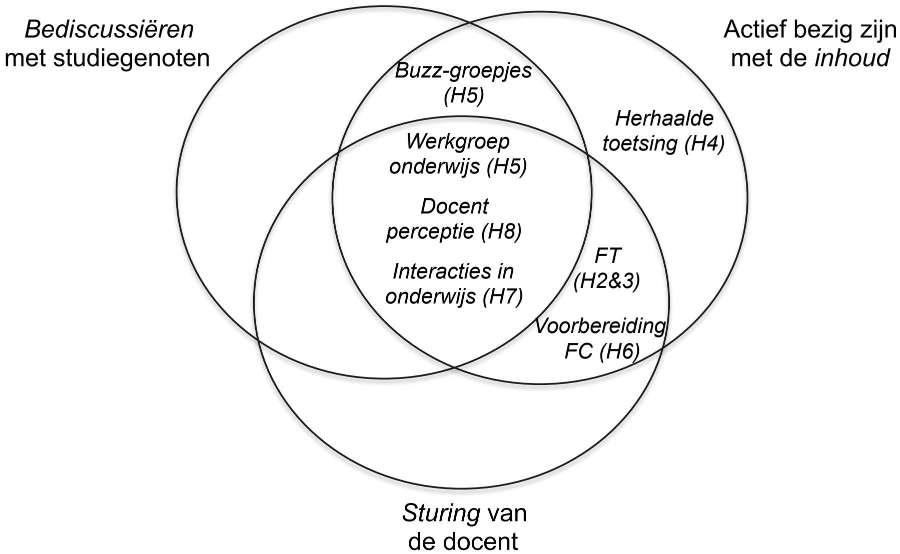
De laatste drie hoofdstukken zijn gewijd het onderwijsconcept flipped classroom. Het doel van flipped classrooms is om het onderwijs interactiever te maken, zodat een beter begrip van de inhoud wordt bereikt. Het is daarbij van belang dat studenten voorafgaand aan het contactonderwijs al kennis verworven hebben, zodat deze kennis vervolgens kan worden toegepast tijdens interactieve lesactiviteiten. In **hoofdstuk 6** werd allereerst onderzocht hoe studenten zich voorbereidden op het contactonderwijs. Hiertoe konden studenten in twee verschillende cursussen aangeven in welke mate verschillende online studiematerialen gebruikt werden. Uit de resultaten bleek dat studenten met name gebruik maakten van weblectures en geselecteerde stukken tekst in de online leeromgeving. Ook maakten zij gebruik van studiematerialen waarmee kennis kon worden toegepast. Alternatieve informatiebronnen zoals wetenschappelijke artikelen en andere studieboeken werden in mindere mate gebruikt. Om inzicht te krijgen in de manier waarop de materialen gebruikt werden, is ook onderzocht hoe dit gebruik samenhing met zelf-gerapporteerde leerstrategieën. Uit de correlatie analyses bleek dat het gebruik van studiematerialen met name samen hing met het hebben van doorzettingsvermogen en het plannen en monitoren van de zelfstudie.

Naast de voorbereiding op het contactonderwijs is ook onderzocht of het "flippen" van het onderwijs daadwerkelijk leidde tot een actievere werkvorm. In **hoofdstuk 7** werd een studie beschreven waarin traditioneel en geflipt contactonderwijs met elkaar vergeleken werd. De vergelijking werd mogelijk gemaakt door de duur en het type interactie te meten met behulp van geluidsopnamen. Er is gecodeerd op activiteiten van de docenten en activiteiten van de studenten. Uit de resultaten van het hoofdstuk blijkt dat er meer interactie tussen de docent en studenten is in geflipt contactonderwijs en dat tweemaal zo veel tijd gevuld werd door studenten, met name door het beantwoorden van vragen. Deze toename werd toegeschreven aan docenten: omdat docenten meer feedback gaven en meer vragen stelden, werden studenten ook meer uitgedaagd om antwoord te geven.

In het laatste empirische hoofdstuk, **hoofdstuk 8**, stonden de docenten centraal. In deze studie werd onderzocht welke kansen en bedreigingen van blended onderwijs werden verwacht door docenten, om deze vervolgens te kunnen vergelijken met de ervaring van docenten die voor de eerste keer flipped classroom onderwijs hadden moeten geven. Het doel van de vergelijkende studie was om te onderzoeken welke werkelijke kansen het blended onderwijs kan bieden, maar ook om inzicht te verwerven in de ondersteuning die nodig is om de nieuwe onderwijsvorm te laten slagen. Er werd een grote overlap gevonden tussen de verwachtingen en ervaringen. De belangrijkste uitkomsten waren dat het herontwerpen van onderwijs een hoge werkdruk voor docenten oplevert, maar ook dat studenten meer tijd aan de voorbereiding van het onderwijs moeten besteden om het contactmoment succesvol te laten zijn. Wanneer studenten goed voorbereid waren, ervoeren de docenten dat het onderwijs interactiever was en de gevoerde discussies meer verdiepend waren.

De uitkomsten van alle individuele studies werden in **hoofdstuk 9** nog eens onder de loep genomen en wel door de studies te plaatsen in het Community of Inquiry model (zie Figuur 1). Dit hield in dat voor iedere studie werd nagegaan of er sprake was van interactie met de inhoud, interactie met studiegenoten en / of interactie met de docent. Volgens het model zou alleen het samenspel van inhoud, discussie én begeleiding leiden tot een effectieve en betekenisvolle leerervaring. Door de uitkomsten van de studies te plaatsen binnen het model kon enerzijds worden verkend welke interacties het meest bijdragen aan effectief leren en kon anderzijds

in kaart worden gebracht hoe de verschillende studie mogelijk verbeterd konden worden.
Uit deze exercitie bleek dat de studie naar herhaalde toetsing (**hoofdstuk 4**) alleen interactie met inhoud bevatte, omdat tijdens de toets niet mocht worden overlegd en doordat de docent geen feedback geven mocht. Op basis van de resultaten kon geen eenduidige conclusie worden getrokken over het beter behouden van kennis. Het model geeft de aanwijzing dat juist het ontbreken van communicatie met studiegenoten en de docent dit zou kunnen verklaren.



Figuur 1. Hoofdstukken geplaatst in het Community of Inquiry model.

Een beter resultaat werd gevonden in de studie waarbij de interactie met inhoud werd uitgebreid met interactie met studiegenoten, namelijk het bespreken van opdrachten met studiegenoten zoals in de buzz-groepjes die onderdeel uitmaakten van de studie naar werkgroepen in **hoofdstuk 5**. Het discussiëren in buzz-groepjes maakte dat studenten de inhoud beter dachten te begrijpen en het gaf hen meer vertrouwen in het vinden van de juiste antwoorden. Deze bevinding mag aantonen dat de interactie met zowel inhoud als studiegenoten van toegevoegde waarde is. Hetzelfde kon geconcludeerd worden voor de interactie met docenten en de inhoud (Figuur 1). De studies naar formatieve toetsen (**hoofdstuk 2 & 3**) en de studie naar voorbereiding op flipped classroom onderwijs (**hoofdstuk 6**) resulteerden beiden in een positieve uitkomst. In deze studies was de docent aanwezig in de vorm van feedback (**Hoofdstuk 2 & 3**) of in de vorm van het maken en selecteren van studiemateriaal dat gebruikt werd tijdens het huiswerk ter voorbereiding op flipped classroom onderwijs. De sturing die studenten hierin vonden, resulteerde in een betere voorbereiding waardoor ook het contactonderwijs beter verliep.

Tot slot werden 3 studies in het midden van het Community of Inquiry model geplaatst, wat betekent dat alle drie de elementen uit het model in die studies vertegenwoordigd waren (Figuur 1). Het ging hierbij om het werkgroep onderwijs uit **Hoofdstuk 5**, en het klassikale deel van flipped classroom onderwijs (**Hoofdstuk 7 & 8**). In beide interventies werd een goede voorbereiding van studenten verwacht (interactie met inhoud), werd er tijdens het contactmoment overlegd met medestudenten om een beter begrip te krijgen (discussie) en was de docent aanwezig om het hele proces te sturen (begeleiding). Uit deze laatste studies bleek dat de studenten veel waarde hechten aan de bevestiging door docenten, maar dat het overleggen met medestudenten het leerproces faciliteerde. De perceptie van docenten gaf ook aan dat de betere voorbereiding van studenten zorgde voor meer verdiepende discussies. Deze resultaten bevestigden dat de interactie tussen de inhoud, discussie en begeleiding inderdaad bijdragen aan de perceptie van een effectieve en betekenisvolle leerervaring.

Een van implicaties die voortkomt uit de verschillende empirische hoofdstukken is dan ook dat bij het herontwerpen van onderwijs aandacht besteed moet worden alle drie de elementen van het Community of Inquiry model. Daarnaast wordt docenten geadviseerd om het beoogde doel van het herontwerp en daarmee gepaard gaande lesactiviteiten tijding met studenten te bespreken.
Wanneer gestreefd wordt naar student betrokkenheid en effectieve en betekenisvolle leerervaringen is het belangrijk om de voorbereiding op het contactonderwijs behapbaar te houden en studenten kennis te laten verwerven op een laag-complex niveau. Voortbouwen op deze verworven kennis en het stellen van vragen stimuleert studenten om actief deel te nemen aan de lesactiviteiten. Ter voorbereiding op de toets is de student gebaat bij specifieke en gedetailleerde feedback dat bijvoorbeeld afkomstig is uit formatieve toetsing. Een goede afstemming van de eindtoets met het voorbereidende werk en alle klassikale activiteiten wordt daarbij geadviseerd.
Al met al zou uit de resultaten van dit proefschrift geconcludeerd kunnen worden dat het introduceren van onderwijstechnologie een bijdrage kan leveren aan student betrokkenheid en effectief en betekenisvol studeren.

Appendices

Curriculum Vitae

After completing higher general secondary education (HAVO) in 2003 and pre-university education (VWO) in 2005 at Edison College in Apeldoorn, with the educational profile 'Natuur & Gezondheid', Rianne started the bachelor program biomedical sciences at University of Amsterdam. She obtained her bachelor degree in 2008, and proceeded with the master program 'Biology of Disease' at Utrecht University. During this program Rianne performed an additional educational internship under supervision of prof. dr. H.V.M. van Rijen. This internship might be considered as the pilot experiment of the second chapter in this thesis.
In 2011, Rianne started working for the Department of Medical Physiology, University Medical Center Utrecht. Here she started her PhD training in combination with a project at the Dutch Heart Foundation. During 9 months she wrote laymen summaries about cardiovascular related issues. At the end of 2012 Rianne joined the organizing committee of the Dutch Physiology Association (NVF). In collaboration with second board member, she organized a 2-day symposium in 2013 and in 2014. At the end of her PhD trajectory, Rianne spend one and a half years as a part time project leader for the evaluation of educational technology constructed by the program 'Onbegrensd Leren' at University Medical Center in Utrecht. In addition to research related activities, Rianne guided multiple seminar learning sessions and laboratory practicals, for this work she obtained the University Teaching Qualification (BKO) in 2015.
As of January 2016, Rianne is working as a teacher and educational researcher for biomedical sciences department (BMS) at University Medical Center Utrecht, the Netherlands.

A

Appendices

List of publications

Publications related to this thesis

Rianne A.M. Bouwmeester, Renske A.M. de Kleijn, Astrid W.M. Freriksen, Maarten G. van Emst, Rob J. Veeneklaas, Maggy J.W. van Hoeij, Matty Spinder, Magda J. Ritzen, Olle Th.J. ten Cate, Harold V.M. van Rijen Online formative tests linked to microlectures improving academic achievement. Medical Teacher (2013) 35; 1044-1046

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Appendices

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Wel zijn er een aantal hoofdpersonen die ik graag een persoonlijke noot zou geven. Te beginnen met mijn promotieteam.
Beste *Harold*, ik verwonder mij nu nog steeds over het feit dat je mij gevraagd hebt om de promotieplek van jouw leerstoel in te nemen. Ik vond (en vind) het werkelijk een eer en ik heb het traject als een fantastische tijd ervaren. Misschien is dit te wijten aan jouw manier van begeleiden, want als ik je moet omschrijven, ben je eigenlijk een promotie-papa. Bedankt voor de enorme kans en al je hulp om hier te komen. Ik zal dan ook niet ontkennen dat ik met veel plezier ben begonnen aan mijn nieuwe uitdaging bij BMS.
Ook mijn 2e promotor, *Olle*, of zoals de autocorrectie vaak schrijft Olé, wil ik in het bijzonder bedanken voor alle waardevolle en zeer leerzame besprekingen op dinsdagochtend. Je kritisch blik op alle figuren, tabellen en niet in de laatste plaats de geschreven tekst heeft absoluut bijgedragen aan het eindresultaat.
De bijdrage van *Renske en Tineke* hebben er vervolgens voor gezorgd dat wij ook echt als een team konden schitteren. Niet alleen op dinsdagochtend, maar ook tijdens het R&D-overleg heb ik echt op jullie steun mogen rekenen. Samen hebben wij het (misschien wat wilde) idee van flipped classroom kunnen laten uitgroeien tot een mooi, maar pittig onderwijsconcept. Daarom *Tineke*, bedankt voor de oneindige toegang tot de speeltuin genaamd 'SUMMA'. Het ontwikkelen van de good practice was alleen mogelijk, omdat het echt een team-effort is geweest. Dit team-effort was mede te danken aan de inzet van *Inge en Eveline*. Jullie keiharde werken heeft er voor gezorgd dat er 3 (to be published) artikelen in dit boekje kunnen staan, merci beaucoupe!
Let wel, deze alinea is natuurlijk niet compleet, als ik *Renske* niet apart zou noemen. Getuige het feit dat jouw naam op ieder artikel en iedere presentatie wordt genoemd, mag wel aantonen dat jij heel veel hebt bijgedragen. Het was altijd gezellig, maar vooral ook heel leerzaam om samen te brainstormen en samen door de data heen te worstelen. Je vrolijke persoonlijkheid en positieve blik op onderzoek werken absoluut aanstekelijk.

Ook mijn (oud-)collega's van de Medische Fysiologie wil bedanken voor de fantastische tijd op deze leuke afdeling. Om te beginnen wil ik *Marc* bedanken. Jij was uiteindelijk degene die mij aanspoorde om de extra stage bij Harold te doen en jij stimuleerde mij (en andere AIO's) om het BKO-certificaat te behalen. Ik heb het niet vaak gezegd, maar ik geef toe dat beide tips goed waren.
Ook de andere stafleden en mede-AIO's wil ik graag in deze laatste pagina's even noemen. Ondanks dat mijn onderzoek totaal niet leek op het werk dat iedereen bij Medische Fysiologie doet, was iedereen altijd bereid mee te denken. Na afloop van werkbesprekingen werden vaak de meest verfrissende vragen gesteld die mij

hielpen op een nieuwe manier naar mijn eigen resultaten te kijken. Daarom *Marcel, Toon, Jacques, Teun, Marti, Martin, Maria, Jet, Bart, Marien en Leonie* bedankt voor het stellen van prikkelende vragen. Na afloop van deze bijeenkomst kon ik met mijn roomies, eerst met *Rosanne* (Het was een eer om bij jouw promotie paranimf te mogen zijn), *Sanne en Magda* en later ook met *Albert*, altijd nog na fantaseren onder het genot van een kopje koffie.
Naast de gezelligheid op de afdeling zelf heb ik absoluut genoten van de jaarlijkse lab-stap-dag en alle gezellige dinertjes en feestjes op de promotiedagen van vele voorgangers. Ik hoop dat ik op 3 november nogmaals kan proosten en een dansje mag doen met jullie allemaal: *Sofieke, Thom, Siddarth, Vincent, Bastiaan* (het was leuk om voor jouw onderzoek af en toe nog even terug te mogen naar 'labland'), *Yuan, Elise, Helen, Hanneke, Iris, Alex* (as promised: thanks for the ride and the funny conversationsJ), *Nele, Birgit en Chantal*. To all colleagues still working on their PhDs: good luck finishing research. In deze lange reeks met namen die horen bij de Fysiologie, is er nog eentje die absoluut niet mag worden vergeten, want waar zou de Medische Fysiologie zijn zonder de steun en toeverlaat van *Tonny*. Jij bent het vriendelijke gezicht dat iedereen warm onthaalt en altijd tijd heeft voor een praatje. Bedankt voor alle gezelligheid, goede raad en ook ons leuke uitstapje naar Soldaat van Oranje.

Ondanks dat het onderwerp van onderzoek niet gelinkt was aan het werk van mijn directe collega's, heb ik bij het bestuderen van flipped classrooms kunnen rekenen op hulp. Zo waren daar *Paulien en Karin* die samen met mij observaties hebben gedaan tijdens de colleges, en hebben *Rianne, Thijs en Renee* geholpen bij het analyseren / coderen en controleren van de data. Hierbij mag ook *Suzan* niet worden vergeten, omdat jij alle interviews met docenten hebt uitgeschreven. Ik wil jullie daarom alle zes bedanken voor jullie fijne hulp. Als ik iets voor jullie kan betekenen mogen jullie dus ook altijd een beroep op mij doen.

Als oud-collega's zou ik ook graag het team van het voormalige 'Onbegrensd Leren' willen bedanken voor de gezellige samenwerking. Tijdens mijn vaste bezoek op maandag aan 4.51 west (*Kirstin, Hester, Sandra, Mirjam, Nannette, Margreet, Eveline en Lonneke*), 4.06 (*Willemien, Geertje, Esther, Sape, Huub, Fiona, Lars, Rens*) en natuurlijk *Cecile* kon er altijd worden gelachen en presteerden we het om aan het eind van het programma een enorme serie mooie producten op te leveren met tevreden gebruikers. Zoals ik in de video bij het slotfeest al zei: "Als ik aan Onbegrensd Leren denk, denk ik aan gezellige collega's en vrolijke verjaardagskaarten". Het werken bij OL was een fijne afwisseling :).

Bespreken van en reflecteren op eigen werk tijdens de verschillende journal clubs in Utrecht en Amsterdam heeft ook zeker geholpen om een aantal artikelen te verbeteren. Ik heb altijd genoten en vaak dankbaar gebruik gemaakt van de verschillende invalhoeken en creatieve oplossingen die er tijdens deze bijeenkomsten werden bedacht. Ook vond ik het erg gezellig om tijdens het AMEE-congres bij jullie aan te mogen sluiten voor het diner en overnachtingen. Daarom een samenvattende 'Dank jullie wel' aan alle *JC-ers*, en in het bijzonder aan *Lindsay, Anouk, Benjamin, Joost, Joris, Renee, Marianne, Jessica, Tiuri, Milou, Alina, Nesibe, Irene en Anita*.

Onderwijskundige theorieën zijn nooit mijn favoriete onderwerp geweest, maar het bespreken ervan tijdens de maandelijkse CTL-meeting heeft me toch geholpen om er een aantal te leren kennen. *Sjoukje, Marijn, Gersten, Thijs, Anouk, Sophie, Chantal, Carrie, Eugene en Margot* bedankt voor de gezelligheid, niet alleen tijdens deze bijeenkomst, maar ook tijdens congresbezoeken in binnen en buitenland.

Natuurlijk kan ik in de lange rij met namen mijn huidige collega's van BMW/BMS niet vergeten. Het voelde als een warm bad om bij jullie te komen werken. De Nerd-alerts en slechte youtube-filmpjes die onder de 12, 13 nee *14 bros' on the 4th floor* worden gedeeld zijn hilarisch. Ik denk werkelijk dat er maar weinig afdelingen zijn waar zoveel wordt gelachen als hier. Het initiatief van de 'Spontane' maandelijkse OWC borrel kan ik dan ook enorm waarderen :).

Ondanks dat ik mijn promotietraject met veel plezier heb doorlopen, bestaan er naast werkdagen ook sportieve touwtrekavonden en te korte maar wel heel gezellige weekenden. Deze weekenden vliegen altijd zo voorbij door de vele feestjes en verjaardagen die er op de Veluwe worden gevierd. En mocht er toch niets gepland zijn, dan kan ik altijd rekenen op een spontane borrelavond in Twello, Beekbergen, Klarenbeek of Lieren. Het is fantastisch om te lachen en wijntjes (of biertjes) te kunnen drinken met jullie allemaal. Ik vind het dan ook ontzettend leuk dat een aantal jullie voor mijn grote dag naar Utrecht willen komen. Daar proosten we op! Van al onze vrienden zou ik *Rene en Sabine* wel even apart willen bedanken, namelijk voor jullie hulp bij het uitzoeken van de feestlokatie en het brainstormen over de kaft. Het was supergezellig en ik hoop dat er nog veel van deze gezellig weekenden te vieren zijn.

Proosten ga ik ook met mijn lieve vriendinnetje *Daniëlle*. We zijn al samen zolang ik mij kan herinneren. Helaas wonen we nu niet meer bij elkaar om de hoek, anders waren we veel vaker op pad gegaan. Want ja, het is altijd lachen om samen met jou te gaan 'shoppen'. Vooral omdat de we de meeste tijd kwijt zijn om van terras, naar terras te gaan. Laat ik traditioneel afsluiten en zeggen: 'Dat moeten we gauw weer doen!' :)

Een speciale toast wil ik graag uit brengen voor de *Labbers*. Nooit gedacht dat het organiseren van een Sinterklaasfeestje er voor kon zorgen dat we ieder (of in ieder geval heeeeel veel) tapasrestaurantjes in Utrecht hebben bezocht en dat wij ook na die stage in het WKZ nog vaak zijn wezen borrelen. Dat het een trouwerij in Parijs en stedentripjes naar Lissabon en London zou opleveren had ik van te voren ook niet verwacht, maar dat het 100-gezellig was, is en blijft een feit.

Naast een van de labbers was jij, *Lotte*, ook nog mijn huisgenoot (2x zelfs). Dit

heeft er voor gezorgd dat wij in Utrecht vaak gezellig samen gingen eten, samen gingen sporten en zelfs hebben deelgenomen aan een mini-cursus salsa dansen. Tegenwoordig ben je vooral mijn stedentrip-buddy. Naast de bezoekjes aan *Maui*, hebben we het mooie Rome en het indrukwekkende Krakow onveilig gemaakt. Gelukkig is ons to-do lijstje nog lang niet afgestreept en daarom hoop ik dat wij nog veel trips gaan maken in de toekomst. *Lotti*, super leuk dat jij mij wil bijstaan als een van mijn paranimfen en 'fenk joe for flying hiberia' (;p).
Aansluitend wil ik ook mijn chica en 2e paranimf, *Jolien*, heel hartelijk bedanken dat je ondanks je recente bevalling naast me wil staan. Wij zijn al heel lang vriendinnetjes en ik vind het ook bijzonder om te realiseren dat wij na de middelbare school totaal andere kanten zijn op gegaan maar nu toch allebei aan een promotie in het onderwijs werken. Hopelijk komen jij, *Martijn* en de kleintjes snel weer in Deventer wonen, dan kunnen we weer vaker koffietjes drinken en terrasjes pakken.

Tom, Corrie en Sander, bedankt voor de belangstelling die jullie constant tonen in het werk wat ik doe. Het is fijn om jullie 'allerliefste schoondochter en schoonzus' te mogen zijn.
Lieve *Cindy en Melanie*, lieve zussen! Als ik mijn twee grootste fans zou moeten aanwijzen, dan weet ik zeker dat jullie dat zijn. Als ik blij mag vertellen dat bijvoorbeeld een artikel is geaccepteerd, kan ik altijd rekenen op de meest vrolijke reacties, een hele dikke knuffel en een smakkerd op wang. In deze feestvreugde doen jullie, *Florens en Joost*, ook altijd even hard mee. Superlief van jullie. Vergeet daarom ook niet dat ik net zo trots ben om ook jullie grote-kleine (tante-) zus te zijn.

Pap en mam, natuurlijk was dit hele feest niet mogelijk geweest zonder de onvoorwaardelijke steun van jullie! Ondanks dat het soms moeilijk te bevatten was wat ik aan het bestuderen was tijdens mijn studie of in mijn onderzoek; bij jullie kon ik altijd terecht voor goede raad en een luisterend oor. Jullie support, in alle soorten en maten, heeft mij het doorzettingsvermogen gegeven om het hoogst haalbare te bereiken. *Pap en Mam* ontzettend bedankt voor alles!!

Lieve *Alwin*, als er iemand in mijn omgeving is die vertrouwen had in het feit dat ik het zou halen, dan ben jij het wel! Zeker het laatste half jaar heb jij rotsvast achter me gestaan. Zelfs wanneer ik een zo gezegd cactus-momentje had, kon ik op jou rekenen. Dank je wel voor alle lieve aanmoedigingen, de honderden berichtjes en smileys via what's-App, de hele stevige knuffels en je brede schouders om op te mogen leunen. Je bent schat! Bij jou ben ik thuis!

A

Uitnodiging

voor het bijwonen van de
openbare verdediging van
het proefschrift van

Rianne Bouwmeester

op donderdag 3 november
om 14.30 uur
in het Academiegebouw
Domplein 29 te Utrecht

Receptie
Na afloop van de
plechtigheid bent u van
harte welkom op de
receptie ter plaatse

Paranimfen
Lotte Boonstra
Jolien Mouw