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# THEORY-DRIVEN DESIGN OF A MOBILE-LEARNING APPLICATION TO SUPPORT DIFFERENT INTERACTION TYPES IN LARGE-SCALE LECTURES

*Research in Progress*

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## Abstract

*Universities face increasing numbers of students leading to increasingly large lectures, and decreasing interaction and collaboration, which are important factors for learning success and satisfaction. The use of IT can help overcoming this challenge by increasing the interaction in large-scale lectures without massively increasing the workload of lecturers. In this research-in-progress paper, we present the design and pre-test of a mobile-learning application aiming to increase the interaction in large-scale lectures and the learning success of learners. For designing our application, we follow a design science research approach. We rely on insights from interaction theory as well as requirements gathered from lecturers and students in a focus group workshop. A pre-test of our application showed high values for Perceived Usefulness, User Satisfaction, and Perceived Presentation Quality for the overall application and moreover high values for Performance Expectancy and Intention to Use of all but one functions. The results show that the application is ready for being used in large-scale lectures. As a next step, the application will be used in one of our large-scale lectures aiming to evaluate whether using our application has a positive impact on interaction, satisfaction and learning success.*

*Keywords: mobile-learning application, design science research, interaction, large-scale lectures*

## 1 Introduction

Universities in many western countries face increasing numbers of students. As a result, growing numbers of learners in lectures and an unfavourable lecturer-to-students-ratio of up to 100 students per lecturer is a common situation. These large-scale lectures are characterized by high anonymity and suffer from a lack of interaction - not only among learners themselves but also among learners and lecturers. Moreover collaborative learning is not feasible in traditional large-scale lectures, where learners are single learners. The results of this decreasing interaction are often deficient learning outcomes and unsatisfied learners. For example, comprehension questions regarding the lecture as well as discussions on specific topics are not feasible, as they are impractical. This development is alarming, since fundamental elements of learning success include the opportunity to ask questions and the possi-

bility of sharing one's opinions concerning the subject matter (Picciano, 2002). Additionally, interaction and feedback are regarded as significant predictors in terms of the learning success (Moore, Masterson, Christophel and Shea, 1996) and positively influence the long-term satisfaction of learners (Alonso, Manrique and Viñes, 2009; Hardless, Nilsson and Nuldén, 2005). It is true that by being actively engaged in the learning process, students will get a deeper comprehension of the subject matter (Evans and Gibbons, 2007). But bringing interaction in a large-scale-lecture is a widespread problem.

A promising possibility to increase the interaction without massively increasing the workload of lecturers is the use of IT. Several researchers have investigated the possibility of mobile technologies to improve the classroom situation (Bitzer and Söllner, 2013; Ratto, Shapiro, Truong and Griswold, 2003). With the aid of IT and mobile devices, interactive data can be transferred between students and lecturers in real-time, which provides potential for improving the interaction in lectures (Dyson, Litchfield, Raban and Tyler, 2009), for intervening in the learning-teaching-environment and enriching traditional courses. The application of IT supported learning and teaching has increased recently in education (Bitzer, Söllner and Leimeister, 2013; Johnson, Adams and Cummins, 2012). The use of mobile devices is widespread. They are flexible in use, easy to use and allow synchronous and asynchronous communication. The current state of research shows that existing learning applications do consider only single types of interaction but not all 3 types of interaction which are proposed by Moore (1989) and no learning application exists which consider interaction completely.

The goal of our research is to develop a mobile-learning application which enables a robust and operational interaction between learners and lecturers as well as among the learners themselves in large-scale lectures. To achieve our research goal, we follow the design science approach (Hevner, March, Park and Ram, 2004; Peffers, Tuunanen, Gengler, Rossi, Hui, Virtanen and Bragge, 2006), particularly the design science research approach of Peffers et al. (2006) (see Figure 1). Moreover, to ensure that our application addresses all important types of interaction, we follow Briggs (2006) theory-driven design approach, by grounding our research in theory on interaction. In this research-in-progress paper, we present details on the first three phases advocated by Peffers et al. (2006) for the development of our mobile-learning application. The introduction has addressed the phase problem identification and motivation. The next two sections describe the objectives of a solution phase by identifying requirements from theory of interaction and from a focus group workshop. We then provide details on the third phase, design and development of our mobile-learning application, before we present a first pre-test that mainly focuses on the quality, especially usefulness and satisfaction, of the application in terms of being ready for subsequent use in a large-scale lecture. The paper closes with our next steps and expected contributions, focusing mainly on our planned demonstration and evaluation of our mobile-learning application, which is expected to increase the interaction between lecturers and learners and among the learners themselves in large-scale lectures and the learning success of the learners.

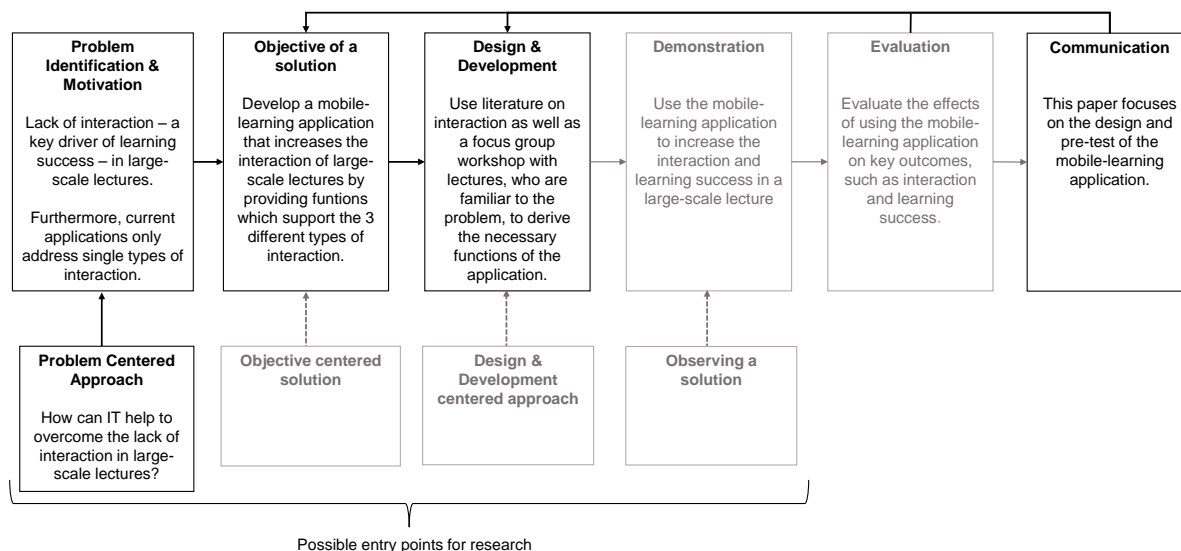


Figure 1. Research approach for developing a mobile-learning application (shaded phases are not addressed in this research-in-progress piece).  
Source: Adopted from Peffers et al. (2006).

## 2 Related work

Mobile learning as a type of eLearning which utilizes mobile devices, and makes learning flexible, spontaneous and portable (Kukulka-Hulme and Traxler, 2005). Hereby, the term *mobile* encompasses learning with the aid of devices outside educational institutions, but also the integration of such devices in a traditional course regarding blended learning (Duncan-Howell and Lee, 2007). One large advantage of mobile devices is their flexible usage: they can be used in class without any organizational effort (e.g. booting time, special computer labs) (Wessner and Dawabi, 2004). In traditional courses the use of mobile devices offers the possibilities to improve the interaction between the lecturer and the student, or that among the students. It can also help to enhance the participation of the students, and the quality of teaching (Wessner and Dawabi, 2004).

*Classtalk* was one of the first tools which was used in lectures pursuing the aim to create a more interactive, student-centered classroom. The tool enhances communication in class, presented questions for small group work and collected students answers for displaying them (Dufresne, Gerace, Leonard, Mestre and Wenk, 1996). The project *ConcertStudeo* activates students by means of handheld-computer, an electronic blackboard and PDAs for the students with brainstorming, a quiz, voting or ranking (Dawabi, Dietz, Fernandez and Wessner, 2003). Using audience response systems or clickers (e.g. *Turning Point*), as they are commonly called, students are able to answer questions in the form of quizzes or self-assessments and are able to provide feedback (Kenwright, 2009). In a contribution made by Wessner und Dawabi (2004) two systems (Haake and Wessner, 2004; Roschelle, Patton and Pea, 2002) are examined using specific design questions (e.g. integration in the learning scenario, distribution of information, interaction). Their results are that both tools are suitable to keep the traditional course advantages but enrich those lectures with different interaction opportunities (Wessner and Dawabi, 2004). One tool of the Wake Forest University (*Class-In-Hand*) offers students the opportunity to answer a quiz via web browser or to provide feedback to a statement on a scale. Thereby the communication is unidirectional from the students to the lecturer (Scheele, Wessels and Effelsberg, 2004). Another type of student-response-system was realized in form of the web application *Swatt* to provide questions in a multiple-choice, true-false, or yes-no format to the students for answering (Shotsberger and Vatter, 2001). Similar to a multiple-choice format is the method Peer Instruction

created by a Harvard professor. Besides answering a short conceptual question interspersed by the teacher, the students should discuss about the question to their colleagues (Fagen, Crouch and Mazur, 2002). The application of Peer Instruction is carried out using mobile devices, i.e., in the project *Pingo* (Reinhardt, Sievers, Magenheimer, Kundisch, Herrmann, Beutner and Zoyke, 2012).

Current research focuses on creating the user interface more intuitive and investigate how to use a high quality presentation of images, videos, etc. despite a small screen size without having to leave out relevant content (Kopf, Haenselmann, Kiess, Guthier and Effelsberg, 2011; Schon, Klinger, Kopf and Effelsberg, 2012; Van Rijsselbergen, Poppe, Verwaest, Mannens and Van de Walle, 2012). Tabata et al. (2010) focuses on an online learning application for the iPhone to support students in answering knowledge questions regardless of time and place. Clunie et al. (2012) present a platform which makes it possible to connect Android mobile devices with the Learning Management System (LMS) Moodle.

To sum up, use of digital media to enhance and to support teaching, especially large-scale lectures, is not new in IS research. But continuous improvement of lectures quality with digital media is still a trend topic. Moreover, the employment of mobile devices in lectures continues to increase significantly (Johnson et al., 2012). Thus, the number of owners of smartphones and tablets among students is growing. Gartner predicts tablet PC sales will reach 327 million worldwide in 2015. The current state of research shows that there exist a large number of tools to enhance interaction and collaboration. But none of these tools consider a set of functions integrated in a single application to enhance the three types of interaction while simultaneously guaranteeing browser and platform independence. Current standard solutions like LMS Moodle or Blackboard are not delivering liberties in design or technical solutions. The LMS Moodle is used at our university. It is not possible to implement and integrate a new function into Moodle. Furthermore anonymity is not guaranteed using Moodle. These are the reasons for the development of the mobile learning application presented here. It is an entirely new design, and is not based on an already existing application.

### 3 Requirements from theory of interaction

The meaning of the term ‘interaction’ in the disciplines of sociology, education and psychology addresses the interrelation between humans and their communicative actions amongst each other (Bryant and Heath, 2000). IT applications can be used to support and enhance interaction. In this paper the prototype is a mobile-learning application which aims at increasing the interaction between learners and lecturers and among the learners themselves and the learning success in large-scale lectures. Regarding interaction, we specifically refer to the work of Moore (1989), in which the author differentiates between three types of interaction: learner-content-interaction, learner-lecturer-interaction and learner-learner-interaction. We adopt those three types of interaction for our paper and define interaction itself as learning activities, including exchange between learners, lecturers and content (Moore, 1989; Schrum and Berge, 1997).

Prior research has shown that learners who interact with their lecturers are more actively involved in the learning process (Liu, Liang, Wang, Chan and Wei, 2003; Wang, Haertel and Walberg, 1990). The question-answer-game is the classic form of interaction found between learners and lecturers. The lecturer can actively include the learner in teaching, assess the learning progress by means of the answers and provide direct feedback. The learners have the opportunity to contribute their ideas and thoughts, thus, also initiating new thought processes (Gagné, Yekovich and Yekovich, 1993; Morgan, 1991). Furthermore, interaction influences the quality of learning in a positive way. A study showing that learners with low or intermediate previous knowledge profit from a high degree of interaction and achieve higher learning results (Snell, 1999).

To increase the interaction, factors which inhibit interaction need to be eliminated. First, when attending large-scale lectures, students often avoid interaction with lecturers because they fear embarrassment in such an impersonal setting (Ratto et al., 2003; Siau, Sheng and Fui-Hoon Nah, 2006). Second,

the seating order of learners (Roth, McGinn, Woszczyna and Boutonne, 1999), the limited time for the study unit (VanDeGrift, Wolfman, Yasuhara and Anderson, 2002) and the fact that it is hardly ever possible to involve all learners in discussions (Siau et al., 2006) inhibit interaction, especially in large-scale lectures. Some learners could fear holding up the whole auditorium with their specific question (Ratto et al., 2003). As is known from the psychology of learning, both the attention and the motivation of students decrease after approximately 20 minutes (Smith, 2001). Thus, it is even more important to employ elements in university lectures which have activating functions. An interactive setting in the learning-teaching-environment can enhance students' motivation, attention and participation in class, as well as foster greater students' exchange (Liu et al., 2003; Sims, 2003). Summing up, we could identify seven requirements from theory to ensure that all three types of interaction are addressed by our mobile-learning application (Table 1).

Interaction type	Description	Requirements
Learner-Learner-Interaction	Learners should have the opportunity to connect with their fellow students during the learning process within conversations and discussions (Alavi, Marakas and Yoo, 2002) to enhance motivation (Eisenkopf, 2010) and learning success (Fredericksen, Pickett, Shea, Pelz and Swan, 2000; Moore and Kearsley, 2011). In collaborative assignments students learn from each other and create new knowledge mutually (Topping, 2005).	T1) Learners should be creating learning material collaboratively. T2) Learners should discuss.
Learner-Lecturer-Interaction	Lectures should give advice and feedback to students and need to retain an overview of their students' performance (Bligh, 1998). In addition, the teacher should verify which learning goals have been achieved or may not have been achieved. In interaction with lecturers, students can request clarification of unclear points and lecturers can reinforce correct interpretation (Thurmond and Wambach, 2004).	T3) Learners should get feedback. T4) Learners should give feedback. T5) Learners should have the possibility to ask questions.
Learner-Content-Interaction	This interaction form takes place when students examine the course content (Moore and Kearsley, 2011) and take part in class activities (Thurmond and Wambach, 2004). Assignments regarding the learning content should be integrated in class. Factors that affect the learner-content-interaction can be contact with the content (Leasure, Davis and Thievon, 2000) and participation in class discussions (Jiang and Ting, 1999).	T6) Learners should get content specific assignments. T7) Learners should get content specific assignments to discuss.

Table 1. Requirements from theory of interaction.

## 4 Requirements from a focus group workshop

Regarding the goal of rectifying the lack of interaction within universities' large-scale lectures, we initiated a lecturers' workshop with eight university lecturers with varying degrees of teaching experience in large-scale lectures. The utilization of focus groups aims to generate numerous innovative ideas (Greenbaum, 1998). To guarantee a systematic collaboration, we chose the collaboration process design approach from Kolfshoten and De Vreede (2009). The task of the workshop was to gather ideas for activating elements for the mobile-learning application to improve the interaction in large-scale lectures at universities. The first activity performed in the workshop was brainstorming in order to collect a variety of ideas to reduce the lack of interaction. In a moderated discussion, each idea was discussed with participants, the redundant ideas were eliminated, and the remaining ideas were evaluated using a Likert scale. Afterwards, the ideas that received the highest scores in the evaluation were discussed. The discussion results in four ideas that we afterwards used to derive concrete requirements for the mobile-learning application. The requirements are the following:

- P1) Even in mass settings learners should have the possibility to give the lecturer feedback to incomprehensible subject matter.
- P2) Learners should be able to ask questions to their lecturer anonymously.

- P3) Learners should create true/false-statements to deal with the learning content and exchange those with their fellow students.
- P4) Lecturer should give questions to the learners who answer and discuss them with their fellow students.

Parallel to the development of the prototype, evaluations involving university lecturers and students took place in iterative cycles. At regular intervals the functions were designed, implemented and tested. The goal of the conducted evaluation was to monitor the graphic preparation of the individual functions. This approach is typical for the so-called *participatory design* (Pilemalm and Timpka, 2008), which is an approach that centres on the user. Consequently, the user is involved as an active participant in the planning, presentation and evaluation of the design process (Pilemalm and Timpka, 2008). Four to six people suffice for each evaluation round in order to obtain a reliable assessment of the results (Nielsen, 1994). The objective regarding the graphical preparation of the individual functions was to realize an intuitive and practical interface which is very easy to use. Lecturers, e.g., prefer to obtain all relevant information for the lecture on a single screen. This guarantees that lecturers are still able to view and control the presentation and use their notes and, at the same time, are still able to monitor the information about the current setting. Moreover it makes it unnecessary to switch between several programs. Based on Olivia (2004), a simple yet clear design should be selected in order to reduce non-data pixels and visual complexity. Every function in the mobile-learning application is represented by a simple, but very characteristic and easily recognizable symbol. This is especially important to avoid a further increase in the cognitive load of the lecturers, to not inhibit the actual transfer of knowledge. The mobile-learning application is separated in two views; one view for the students and another view for the lecturer. The following figures show an extract of the application; separated into the two views.

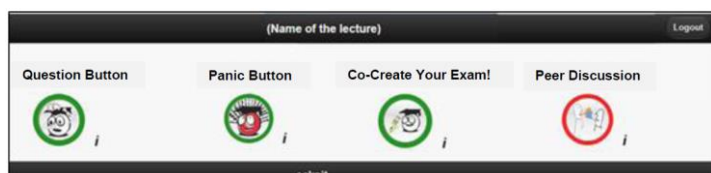


Figure 2. Screenshot of the functions of the students' application.

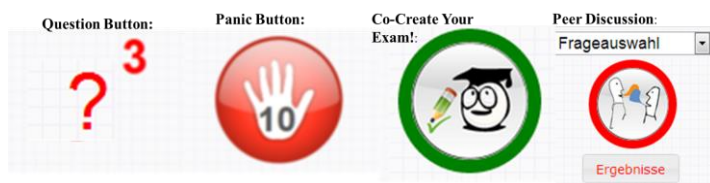


Figure 3. Screenshot of the functions of the lecturers' application.

The functions in the mobile-learning application are aimed at increasing the activation and enabling a robust and operational interaction. The design of the functions is the final result of the participatory design aiming an ease of use for the users. Students are able to use the application place synchronous or place asynchronous, since the lecture is broadcasted via livestream during the class. Access to the application for both students and lecturer is via a URL. There is no ex ante registration necessary to ensure anonymity. In Table 2 we describe the four functions. The embedding of activating functions in a large-scale lecture stops passiveness during lecturing (Snell, 1999). All functions aid the realization of interaction, which Moore (1989) differentiates.

	Functionality	Design	Requirements
Question B.	Students can send their questions to the lecturer anonymously. The questions are answered by the lecturer during class or in the class-concomitant forum. In addition, the system allows automatic email forwarding from incoming questions to the lecturer.	The number of questions asked by the students light up red for the lecturer and can be read from the lecturer in a separate window in chronological order.	T5, P2
Panic Button	Students can press the panic button to send a signal to the lecturer about incomprehensible content. The button can be used during the whole lecture.	The panic button lights up orange on the lecturer's application if it has been clicked by a student. If a predetermined number is exceeded, the button will light up in red as a special signal to the lecturer.	T4, P1
Co-Create Your Exam!	To a certain time in class students generate true or false statements dealing with the content they just heard. Statements are answered and evaluated by colleagues. Moreover the lecturer gets randomly selected statements for answering and evaluating using a projector. The application allows exporting the generated statements. They are then available via the university's LMS and students can use them as exercises. To a certain extent, the statements are used for the exam, thus enhancing the incentive for students to work with the study content and produce high quality statements.	Using the Co-create button opens new windows for in- and output in both applications. Learners and lecturers can rank statements with a five-point-star-rate.	T1, T6, P3
Peer Discussion	The lecturer can send single-choice questions with five predetermined answers to the students. First of all each student answers the question alone. Second, each student shall discuss the question to their colleague. Third, each student has to answer the question again. The lecturer can hereby evaluate the learning success of the students and give them direct feedback.	The results of the vote are calculated in real-time and can be shown by the lecturer using a projector. This function is the only one that must be activated by the lecturer and is not available for using outside class.	T2, T3, T7, P4

Table 2. Description of the functions of the mobile-learning application.

## 5 Evaluation

To assess the quality of our application, we conducted a pre-test aiming to answer the question whether the application is ready for being used in a large-scale lecture. Therefore, we used the application at the end of a large-scale lecture on fundamentals of information systems. The students received an introduction on the functions of the application, could access it via their mobile devices and were asked to use it during the lecture. Participation was voluntary. The lecture was designed in a way that all functions of the application could be used. Afterwards, the students were asked to complete a questionnaire containing the necessary items for our evaluation. All items were measured using a bipolar five-point Likert response format with the endpoints labelled as "I disagree" and "I agree." In total, 49 questionnaires of the 85 class-attendees (response rate 58 %) could be used for our evaluation.

Due to our interest on the usefulness and satisfaction of the application, and the fact that there was no incentive for the students to complete the questionnaire but their goodwill, we decided to keep the items to a minimum and focused on the constructs: Perceived Usefulness (PU), User Satisfaction (US), and Perceived Presentation Quality (PPQ) for the overall application. Furthermore, we assessed the Performance Expectancy (PE) and Intention to Use (IU) for every function to gather more detailed feedback on the quality of different functions. The results of the evaluation are presented in Table 3.

Regarding the measurement of our constructs, we relied on scales provided by previous studies. Furthermore, the values for Cronbach's Alpha and indicator loadings fulfilled the requested thresholds (Chin, 1998; Nunnally, 2010). Further, the mean values for all but one constructs are significantly higher than the neutral point of the scale ("neither agree nor disagree"). This indicated a high PE and IU of all but one function of our mobile-learning application. Only the panic button received compara-



bly low scores for both, PE and IU. The overall application received high values for PU, US and PPQ. Consequently, our application in general is ready for being used in a large-scale lecture, but the usefulness, design and presentation of the panic button should be reinvestigated.

Construct	No. of items (References)	Mean	Standard Deviation	Cronbach's Alpha	t(df) = t-value, p-value
PE – Question Button	4 (Venkatesh, Morris, Gordon and Davis, 2003)	3.51	1.40	.910	t(48) = 3.530, p < 0.001
PE – Panic Button		3.18	1.40	.960	t(48) = 1.220, n.s.
PE – Co-Create		3.92	1.13	.937	t(48) = 6.262, p < 0.001
PE – Peer Discussion		3.62	1.31	.960	t(48) = 3.919, p < 0.001
IU – Question Button	4 (Söllner, Hoffmann, Hoffmann, Wacker and Leimeister, 2012)	3.64	1.32	.979	t(48) = 3.508, p < 0.001
IU – Panic Button		3.42	1.44	.973	t(48) = 2.192, p < 0.05
IU – Co-Create		4.08	1.20	.978	t(48) = 6.517, p < 0.001
IU – Peer Discussion		4.08	1.10	.981	t(48) = 7.054, p < 0.001
PU – mobile-learning application overall	6 (Davis, 1989)	3.99	1.01	.971	t(48) = 7.336, p < 0.001
US – mobile-learning application overall	7 (Arbaugh, 2000)	4.11	1.03	.967	t(48) = 7.660, p < 0.001
PPQ – mobile-learning application overall	3 (Wells, Valacich and Hess, 2011)	3.90	0.81	.950	t(48) = 8.195, p < 0.001

Table 3. Evaluation of measurement model and summary statistics (N=49).

## 6 Next steps and expected contribution

The results of the pre-test regarding the panic button did not show satisfactory results. Possibilities could be different students' learning styles. Another reason could be inaccurate feedback from the teacher which didn't map on students' expression while using that button. Consequently, we will adjust this button. An idea we got as feedback from a lecturer was to adopt each panic vote to a specific slide in the lecture material. That will give a direct feedback to the learning material. For our future research we plan to employ the mobile-learning application in our large-scale undergraduate lecture on fundamentals of information systems. Additionally, the application is offered to other departments to conduct additional evaluations. The goal will be to extensively test the application and collect feedback for further development. These activities resemble the *demonstration* phase of Peffers et al.'s (2006) design science research process. The goal of using the application in different large-scale lectures is to comprehensively investigate the application's effect on interaction and learning success (*evaluation* phase).

One issue that limits our results is regarding the response rate of 58%. It is possible that only students who liked the tool participated in the evaluation and the remaining 42% didn't like the tool. This effect would bias and limits our results. However, after the evaluation had ended we cannot make specific analyses of that. After the comprehensive evaluation of our application, we expect to be able to show whether the application is useful in terms of increasing the interaction of large-scale lectures and creating the positive effects in learning success. We expect the results of this upcoming evaluation to offer different contributions to research and practice. First, we create empirical results on the relationships between the different kinds of interaction and learning success. Second, we provide an evaluated approach on how to design a mobile-learning application based on theory as well as input from practitioners. Third, assuming we can show effects purported in theory, we provide an evaluated and ready for use application increasing the interaction of large-scale lectures and the learning success of the students.

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