
Mobile and contextual learning: a case study on mobile didactics in teaching and education

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Abstract: Smartphones, as ubiquitous companions in all activities of daily living (ADLs), have also been adopted in educational contexts. Mobile applications go along with novel interfaces and ways of interaction, converging towards the vision of *Ubiquitous Computing* (Weiser, 1998). In this article, we provide an up-to-date overview of the demand on mobile services in higher education and learning environments grounded on two large-scale studies. We investigated the current use and the demand of online campus services among students and academic staff at a university of technology. In a follow-up study, we focused on the demand of mobile learning applications. We identified requirements for a didactics application in higher education as an example for ubiquitous mobile learning support. We introduce the *MobiDics* application, describe its didactic foundation and its implementation. *MobiDics* allows ubiquitous didactic training, adapted to personal needs and contexts. We conclude by outlining some future perspectives for didactic teaching support.

Keywords: mobile learning; context-based learning; mobile interaction.

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1 Introduction

How do we become good (or even better) university teachers? New faculty members have, unless given a natural talent, to learn to teach in a structured and methodological manner. This facilitates better learning success and information mediation and is intended to result in the desired learning of competences on the learner's side.

But how can teachers learn about didactic skills and teaching methods? Most universities nowadays have started to acknowledge that teaching competences are an integral part of the skill set of their academic personnel and offer educative didactic courses. In these courses, didactic experts explain teaching methods and approaches and exercise them e.g. in role plays. This is a good way, especially for new faculty members, to acquire the required methods, increase their teaching success and increase thereby their satisfaction with their own teaching.

Teaching *teaching* is a valuable and successful approach towards increasing the teaching quality. There are also lecturers and academics that, for various reasons (shame, pride, advanced position, etc.) who would not participate in these offers and would prefer e.g. books or web resources to satisfy their needs on didactic information material.

We in this paper present *MobiDics*, a platform supporting both mobile and blended learning of didactic methods for academics and teachers. The idea is to support an as wide as possible range of people with increasing their didactic teaching skills. By exploiting context-aware and context-sensitive features, both provided by the mobile device (e.g. location), the user (e.g. type and size of courses taught, teaching experiences and style, etc.) and the environment (e.g. size of the rooms, available materials such as projectors, etc.), we aim at providing situated and personalised access to didactic teaching methods. In addition to an ad-hoc and demand-oriented access to this information, we also offer a web-based access via standard web browsers. This modality is intended to support the structured preparation phase of courses, materials, and methods and thereby complementing a potentially arising ad-hoc demand (e.g. during a lecture break when the lecture itself 'did not run good').

We believe that we need to support, in addition to mobile learning (m-learning) and blended learning, also different usage styles and thereby context-sensitive adapt to the development of an academic or lecturer: While when starting to learn about teaching methods, there more probably exists a need for structured access (like a database lookup), this will, as we argue, need to follow the development of the lecturer's teaching personality: from pure information access to sharing experiences with the peer group of lecturers (like a community or discussion forum) and then eventually converge towards the goal of receiving coach-like support. We argue that with the increasing maturity of the lecturer, the needs will further change towards an optimisation of the teaching personality, e.g. addressing higher-level goals, e.g. from good information mediation to e.g. increased interactivity during the lecture.

The article is structured as follows. First, we give an overview of related work on mobile services at universities and mobile learning in Section 2. Afterwards, we investigate in Section 3 the current use and the demand of online campus services among students and academic staff at a university of technology. In a follow-up study, we in Section 4 focus on the demand of mobile learning applications. Based on a video prototype, we identified requirements for a didactics application in higher education as an example for ubiquitous mobile learning support. We subsequently, in Section 5 introduce the *MobiDics* application, describe its didactic foundation and its implementation. We believe that such applications can foster peer learning and contribute to better university teaching. We conclude with an outlook on future work on the *MobiDics* system in Section 6.

2 Related work

2.1 Mobile services at universities

We in the following consider mobile services as context-based services (CBS) where real-world and digital data are utilised to deliver a certain service or experience to a mobile user. We also report on educative environments.

Classroom 2000 (Abowd, 1999) at Georgia Institute of Technology was one of the first deployed projects to support learning with mobile devices. Besides instrumented rooms that support lecture capture, mobile personal interfaces (tablet PCs) were used for live-annotating lecture slides, which could afterwards be accessed as HTML pages. In the next step, rooms were instrumented with cameras, microphones and electronic whiteboards as 'living laboratory'.

Universities often also offer mobile services for course management, internal news and campus maps that go beyond the conventional websites viewed on mobile devices. As examples shall be mentioned iLancaster¹, MIT Mobile² and the CMU App³. Berg et al. (2007) suggest a stronger integration of social networks and campus services, while Wheeler and Waggener (2009) present ways how cloud computing could contribute to new services and applications.

2.2 Mobile learning

E-Learning is meanwhile widely adopted by colleges and universities, e.g. by introducing and using online, collaborative tools such as the Moodle platform⁴. Also, distance-based

learning is nowadays facilitated with the established e-learning tools (for a review, see Garrison, 2000). Newer trends address e.g. context awareness in learning (Wang, 2004), the role of mobile learning systems in teacher training (Seppälä and Alamäki, 2003; Möller et al., 2011a, 2011b) and ubiquitous learning (Looi et al., 2009; Ogata et al., 2011).

With the rise of tablets, handhelds and smartphones, mobile learning support has recently continuously grown (for a review, see (Naismith et al., 2004)). Thereby the new field of m-learning is defined (Sharples, 2000; Tatar et al., 2003). Those devices allow using learning materials on the go, such as lecture notes in PDF format or podcasts. They facilitate time- and location-independent learning, e.g. on journeys or outdoors. Infrastructures like iTunes U⁵ facilitate the distribution and download of digital educational resources or even complete online courses. Beyond that, digital market places, such as the Apple App Store⁶ or Google Play (formerly Android Market)⁷, offer apps that are targeted at specific learning tasks and contexts. They range from vocabulary trainers to simulations and educational games. Mobile learning applications are also suitable for experience-based learning in mobile contexts, e.g. in the medical area (Sharples, 2000; Holzinger et al., 2008), apprenticeships (Tatar et al., 2003), and they can be used for lifelong learning (Pham-Nguyen and Garlatti, 2008). Besides offline learning and conventional e-learning, mobile learning is an additional way of accessing resources and acquiring knowledge. This is supported by the possibility of the mobile app to suggest didactic methods e.g. based on user preferences or user or lecture context, such as the configuration of the lecture room. This information can e.g. be retrieved from a university campus information system based on device positioning using e.g. WLAN signals indoors (Kranz et al., 2010; Möller et al., 2012a, 2012b, 2012c). Its increased flexibility in time and location opens up new learning scenarios, in which traditional e-learning material is not or only in a limited way accessible.

MLE (Mobile Learning Engine) is an extension of Moodle for mobile devices (Holzinger et al., 2005). The original Moodle⁸ system, which is meanwhile quite established as e-learning platform on many universities, offers online e-tests and learning units as complement to traditional courses. In MLE, so-called MILOs (Mobile Interactive Learning Objects) adapts this functionality for mobile devices. MILOs contain small pieces of information, e.g. text, images, questions or multimedia elements. This chunk structure shall foster explorative learning where the learner can choose the amount and order of units. In addition, interrupting and continuing learning, which is typical for mobile settings, is better supported. Self-organisation of learning content is seen as an additional motivational factor. However, the lack of a predefined learning path makes the system probably not appropriate for beginners. A further extension of this system are XLOs (X-Media Learning Objects), which make the learning content accessible on a greater variety of devices, e.g. MP3 players, PDAs or TVs (Holzinger et al., 2008). They thereby transport the idea of 'pervasive learning': learning can take place at every location at every time, and content is seamlessly accessible over heterogeneous devices.

The heterogeneity of learning tools not only comprises their size (from the small smartphone to the large television set), but also the involved senses. Multimodal learning includes more than one single human information channel; it combines e.g. vision, sound and haptic experience. The learning process thereby becomes more sustained, but also more playful, which increases fun while learning (Holleis et al., 2006; Leichtenstern et al., 2007; Vodvasky et al., 2007). Such multimodal learning systems can be created by enhancing physical objects with digital technology and thereby combining them with the advantages of e-learning. These so-called 'smart' or 'tangible' objects allow situational

and playful learning by experimentation. An example is the SensorVirrig (Schmidt et al., 2004), a cushion with integrated ball switches, a compass and a pressure sensor, that can be used to control objects in learning games, or the display cube (Terrenghi et al., 2006) as a playful interaction device for kids. Besides ‘pervasive learning’ at home or other places, such smart objects could also be used at schools or universities and enhance and complement traditional lessons. Existing e-learning and m-learning systems focus on tools, but not on the methodology of learning concepts that are appropriate from a didactic point of view. Hence, existing didactic knowledge is required for using these tools. Information on the didactic background of tool support, course structuring and knowledge transfer can be found online in form of wikis or training videos. However, to our knowledge, no e-learning or m-learning tool includes didactic background knowledge for university education.

3 Mobile services at the university

3.1 Survey on mobile services in education and learning

The young and technophile population at colleges and universities suggests a high smartphone coverage (backed up by the number of 6 billions mobile phone subscriptions worldwide in 2011⁹), making ubiquitous services useful and willingly adopted. In order to investigate this potential and current smartphone and mobile service usage habits, we conducted an online survey with 93 participants. About 65% were students at our university, about 21% were academic staff. 2% were students at other universities and 12% belonged to neither category (e.g. other faculty staff). The invitation to the survey was distributed using a university-internal mailing list (mainly addressing staff), the faculty’s online discussion board (mainly visited by students) and via Facebook.

The survey consisted of three parts. First, we asked for the *mobile phone internet usage*. Access to 3G internet or free university WLAN is a requirement to use online services. We asked how often users’ phones are connected to the internet and which services they use. Second, we gathered information about which *university services* people use frequently (not necessarily mobile). This helped us to get an impression of what information and services are actually popular with users. Third, we wanted to know which *mobile university services* users would like to use with mobile phones. This helped us to identify how services can better be adapted to mobile devices in order to be adopted by users, and which novel services and applications could be provided to satisfy users’ demands, using the potential of state-of-the-art smartphones.

3.1.1 Results and discussion of the study

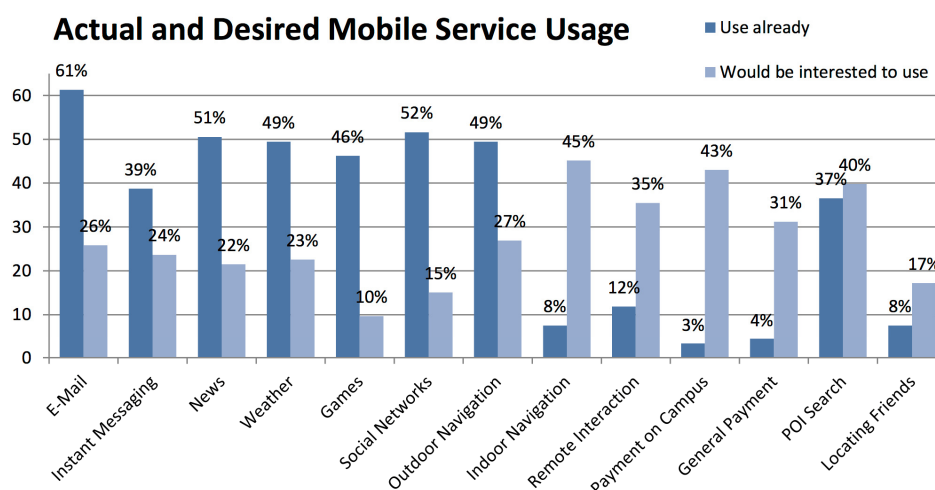
Mobile phone internet usage

Results: 39% of the survey participants have a permanent internet connection on their mobile phone; 18% are online via WLAN on campus, and 17% establish a connection when needed. 28% state they don’t use mobile internet, because they either don’t need it, find it too expensive or don’t have an internet-capable mobile phone.

E-mail (61%), social networks (52%), news (51%) and weather information (49%) belong to the most frequently used services on smartphones (see Figure 1, ‘use already’ columns). Out of the more uncommon services we had added to the questionnaire,

subjects would be most interested in using indoor navigation (45%), payment with their smartphone on campus (43%), searching for nearby POI (40%) and remotely communicating with interaction points in the environment (35%).

Figure 1 Usage of mobile services on smartphones. ‘Classic’ activities and applications such as email, weather forecasts and social networks are widely used, but there is also a demand for novel applications like mobile payment or indoor navigation (see online version for colours)



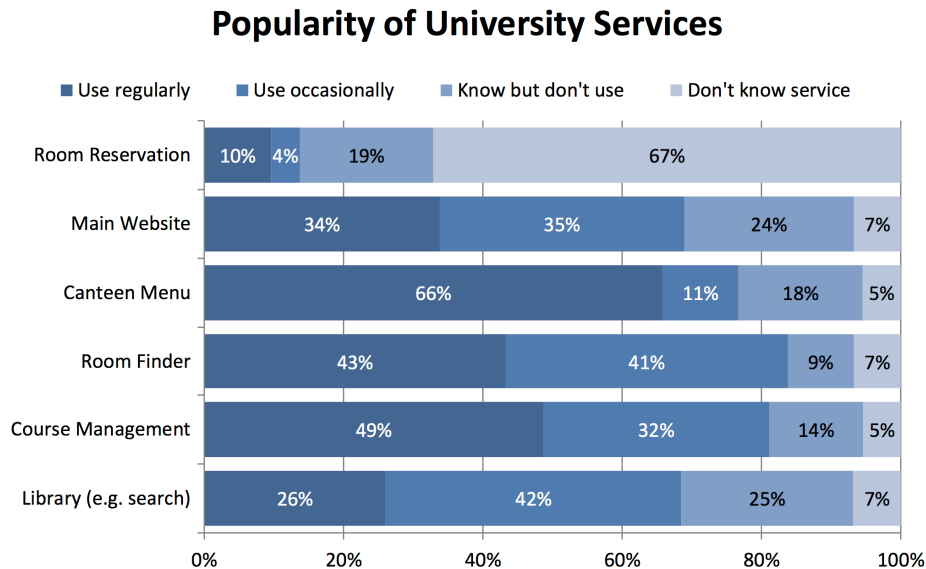
Discussion: A good three quarters of users can be addressed with mobile services on campus, while the user group owning non-capable phones will most likely further decrease in the next years. To further foster the spread of mobile services at universities, two measures can help: A university-wide free WLAN (such as the world-wide available WLAN network EduRoam¹⁰) addresses users with no free data plan, and attractive services motivate users to activate their internet connection to be able to participate.

As Figure 1 indicates, such attractive desired features are indoor navigation, payment for university services (digital wallet), search for points of interest and interacting with the environment. Here is actually a potential for future applications to implement them by making use of new possibilities that modern smartphones offer.

3.1.2 Stationary university services usage

Results: Figure 2 illustrates how campus-related services are currently used at our technical university (Technische Universität München). Results might differ e.g. for universities focusing on social sciences. For each service, participants could indicate whether they use it regularly, occasionally, not at all, or whether they do not even know about it. The room finder website and the online course management tool are most frequently used regularly or occasionally by 84% and 81% of participants, respectively, followed by the canteen menu website (77%) and the university’s main website (69%). The canteen menu is by far more checked out regularly (66%) than the other tools, which are often only occasionally used.

Figure 2 Usage of selected university services (stationary and mobile), from left to right ‘use regularly’, ‘use occasionally’, ‘know but don’t use’ and ‘don’t know service’ (see online version for colours)



Discussion: Many of the major university-related services we selected are not too frequently used. Particularly the interactive services are willingly adopted, like the room finder or the course management tool. The comparatively high amount of people who know about, but do not use the library site (25%) and main web portal (24%), which are both static websites, shows the demand for more interactive, user- and task-centric offers. One option to more widely raise interest in other services could be to piggyback information, e.g. in the canteen service.

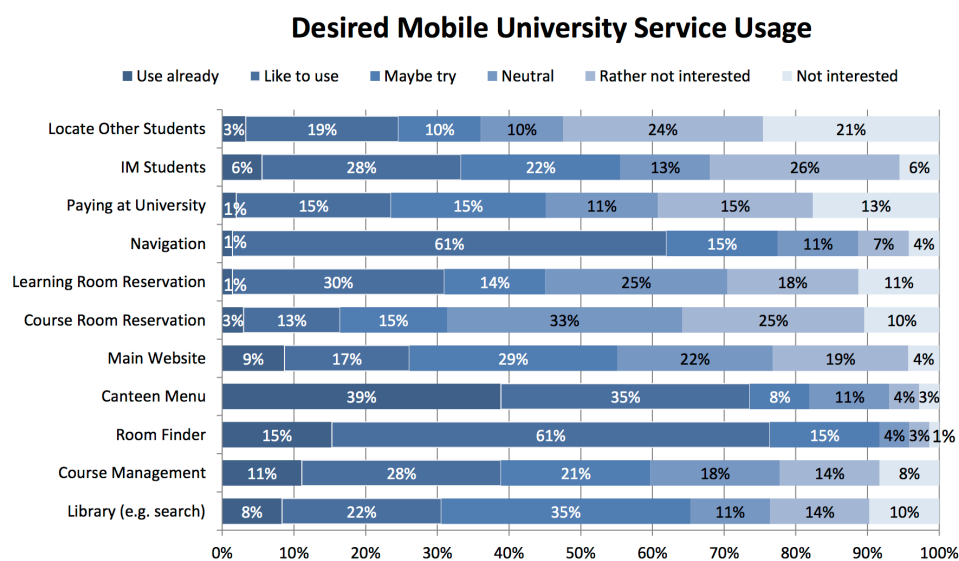
3.1.3 Actual and desired mobile university services usage

Results: Figure 3 summarises the participants' attitude towards selected mobile university-related services, and their actual usage. For each service, participants could state whether they already use it, or if not, whether they would be interested to use it on a five-step scale from 'like to use' over 'neutral' to 'not interested'. The highest interest was attested the room finder and indoor navigation. 61% of participants would like to have this as mobile service; 15% would maybe try it. Subjects would also like to be able to reserve rooms for learning (30%), manage their courses on the go (28%) and use instant messaging (IM) with fellow students (28%). Library search, locating other students in a Foursquare-like manner and using mobile payment (e.g. for photocopier or canteen) found 22%, 19% and 15% interesting. There was also a demand for accessing the university's main website in an optimised mobile version (17%).

Discussion: Except for the canteen menu which is used by 39% of subjects on mobile devices, university services have not yet really found their way towards smartphones. The results for this survey question suggest two things: Firstly, there is a desire for entirely new services, such as social applications with focus on the university (instant messaging students) or indoor navigation. These are applications that are technically

feasible, using the features of state-of-the-art smartphones such as NFC for campus payment, or WLAN localisation for indoor location-based services. Not for all services infrastructural changes are required; indoor positioning can e.g. be realised by WLAN localisation or by other RF-based communication systems (Honkavirta et al., 2009; Kranz et al., 2010), just using the existing access point infrastructure. If novel vision-based approaches are used (Hilsenbeck et al., 2012; Möller et al., 2012a, 2012b, 2012c), the environmental infrastructure even does not have to be changed at all.

Figure 3 Students and university staff are particularly interested in navigation, room finder and social services like instant messaging. From left to right ‘use already’, ‘like to use’, ‘maybe try’, ‘neutral’, ‘rather not interested’, ‘not interested’ (see online version for colours)



Secondly, there is a desire to use existing services on smartphones, even though they are theoretically usable by their standard websites. This is apparently not appealing enough, indicated by the fact that e.g. the room finder at our institution is only used by 15% on mobile devices. However, especially such location-based search and navigation are predestinated to be used from mobile devices. They should be ported to mobile versions, e.g. by adaptations to screen sizes, limited text input possibilities and mobile interaction paradigms like gesture navigation, or by creating individual apps that better support specific tasks. Implicit knowledge provided by the device (e.g. proactive services based on the user's location or preferences) can further simplify the usage of such services.

3.1.4 Summary of the study

Our findings can be summarised in three main points.

- There is a high coverage of mobile devices that are connected to the internet, providing a strong basis for mobile services and applications on campus. The survey suggests further a demand for using such services on mobile devices among university students and academic staff.

- More existing services and applications should be provided for mobile usage to satisfy this demand. The discrepancy between actual and desired usage of such applications indicates that services need to be improved for a higher acceptance on mobile devices. They need to be stronger adapted to the special possibilities and requirements of these devices – and the learning environment. This includes adaption to smaller screens and different ways of interaction with the device (e.g. gesture navigation), as well as between device and environment (e.g. remote interaction through near field communication or visual markers). The use of implicit information, such as user context (inferred e.g. from sensor or usage data), can further simplify usage of applications and facilitate situated services tailored to the users' need.
- There is not only a demand for adaption of existing services, but for novel applications as well. These include payment applications, e.g. for photocopiers, coffee machines or in cafeterias; remote interaction with e.g. situated displays, and particularly location-based search of and navigation to 'campus POI', such as the nearest photocopier, the nearest free room for learning, or a faculty member's office. Such services need to go along with appropriate intelligent interfaces in order to make them accessible from mobile devices and to make their usage attractive and simple.

Some key requirements are needed for these points. First, the university must provide a good WLAN coverage in order to achieve a wide user basis and to incorporate users with phones without permanent online connection (flat rate). Second, an indoor positioning system is a requirement not only for navigational instructions that were an explicit desire of users, but also the basis for other indoor location-based services like search of nearby POI. For a survey on WLAN-based indoor positioning systems, see Honkavirta et al. (2009). With the present denseness of access points in universities for 'everywhere WLAN', positioning on room-level accuracy is possible with state-of-the art fingerprinting methods. For large-scale public indoor environments, such as universities, visual localisation (Hile and Borriello, 2008; Möller et al., 2012a, 2012b, 2012c) could also be an interesting alternative. Finally, as in our survey participants sometimes stated that they would 'like to use' mobile services which are already available, a good information policy regarding new applications is important, in combination with transparent privacy statements giving users control over their data.

3.2 *Summary and discussion*

In this case study, we investigated on current mobile phone and university service usage (stationary and mobile), and the demand for mobile services and applications related to the campus. We identified a demand for mobile adaptations of existing services as well as a high interest in novel applications like indoor location-based services and interaction with the environment. Based on our results we pointed out directions towards more ubiquitous applications on campus, improving the service level and fostering the connectedness of staff and students.

4 MobiDics – a context-sensitive mobile learning tool

In this section, we motivate and assess the demand for a context-sensitive learning app. The implementation is described in Section 5.

4.1 Motivation

Computer-supported learning (e-learning) is meanwhile an established component in school and university teaching, and used as a complement to traditional, ‘offline’ learning. Such combinations are referred to as blended or hybrid learning (Martyn, 2003). The risk is, however, that educational games, e-learning and simulations in learning contexts replace a didactically grounded course preparation (Dragana et al., 2007). Teachers still need a profound didactic knowledge to develop learning concepts and to structure their courses, be it offline, online or any combination of them (Ramsden, 1992).

In many countries, university courses are not held by dedicated, full-time lecturers, but by associates without explicit didactic education or PhD students (Winteler, 2001). Such personnel often have little teaching experience and often a limited didactic knowledge, which was confirmed by the results from a survey we conducted with more than 100 people involved in university teaching. We therefore argue for increased awareness for didactically profound course preparation, and for tools that provide teachers with the necessary didactic knowledge to manage this task.

We address this problem with MobiDics (‘Mobile Didactics’), ‘a didactics toolbox for the pocket’. MobiDics is a mobile e-learning platform aiming at university teaching personnel. Both available mobile learning apps on the market and currently ongoing research focus mainly on learners, i.e. students. With our work, we address teachers and lecturers at universities. Based on the knowledge they acquire when using our system, they can improve their lessons, from which, in turn, the students benefit. Of course, teachers in that context can be seen as learners as well. The system encourages the use of didactic methods, adapted to a particular teaching situation. It thus goes not towards blended or online learning like other student e-learning platforms, but explicitly focuses on improving learning in classic classroom settings. We see our tool as a connecting link between mobile e-learning systems and traditional offline learning.

In this section, we motivate the MobiDics platform with the demand in the target group of professors, lecturers, PhD students and didactic professionals. We gained insights about information sources for lecture preparation and associated problems. In the subsequent section, we will present the actual MobiDics system and describe its features and implementation.

4.2 Survey of demand

In order to lay the basis for target-oriented development of mobile learning applications, we conducted an online survey with 103 people involved in university teaching – mainly PhD students (43%), lecturers, professors, etc. (Möller et al., 2011a, 2011b; Meyer et al., 2012; Möller et al., 2012a, 2012b, 2012c). Our goal was the assessment of demand for tools supporting them in course preparation. We also evaluated general smartphone usage in the target group to find out whether a mobile application has the potential of being applied. Data on that specific group had so far not been available. Furthermore, we asked

for their problems with lecture preparation, consideration of didactic methods, and whether people were satisfied with their current lecture preparation from a didactic point of view.

4.2.1 Method

The survey was conducted as online questionnaire consisting of seven questions, distributed over five screen pages. The possible response options were to be selected via checkboxes (multiple choice possible). For questions where further options were possible, we added an optional free text field. The MobiDics prototype was demonstrated in an embedded video in the survey website. The users' dwell time on the screen page was recorded, in order to drop out responses of participants who obviously did not take the time to watch the video.

On the last page of the questionnaire, we asked for statistical information (age, gender, university, profession, and department). All data was recorded anonymously. Participation in the study was voluntary.

4.2.2 Participants

Participants were recruited from didactics courses at the Centre for Higher Education associated with our university (Carl-von-Linde-Akademie). 53 participants were female, 50 were male; the average age was 32.9 years (standard deviation=8.8).

The largest part of subjects was PhD students (43%), followed by postdocs (15%). These groups seem to have a high interest in didactics, as they are involved in teaching but have little experience yet. Assistant professors were represented with 12%, new or junior professors with 3%, and experienced professors with 6%. 15% belonged to other groups, such as lecturers, trainers or faculty administratives.

28% of participants come from technical departments (electrical and informational engineering, mechanical engineering and similar), 17% from natural sciences (physics, chemistry, medical science bioscience and related), 16% are computer scientists. These high numbers are due to our university being a university of technology. Furthermore, 12% of survey participants are members of social science departments, 8% belong to the educational area and 7% to the department of economics. The remaining 14% were members of various other institutions, faculties, and other universities.

4.2.3 Results and implications

92% of the survey participants are smartphone owners and use it regularly. Given that a broad basis of users has access to the internet using a mobile data plan or university WLAN (see our previous survey on campus service usage in Section 3), the technical barriers are reduced to a minimum.

After email (92%), information search was the second most widely performed activity on the smartphone (79% of smartphone users). These numbers show that the technical basis for mobile didactics (smartphone coverage) is available in the target group. They also indicate that the smartphone usage for information research and consumption (thereby also potentially on didactics), seems adequate for the target group.

Asked about their course preparation, a considerable number of subjects stated in the free text answer field that they rarely used specific didactic methods. We identified the following main reasons for spare usage of didactic methods based on subjects' answers:

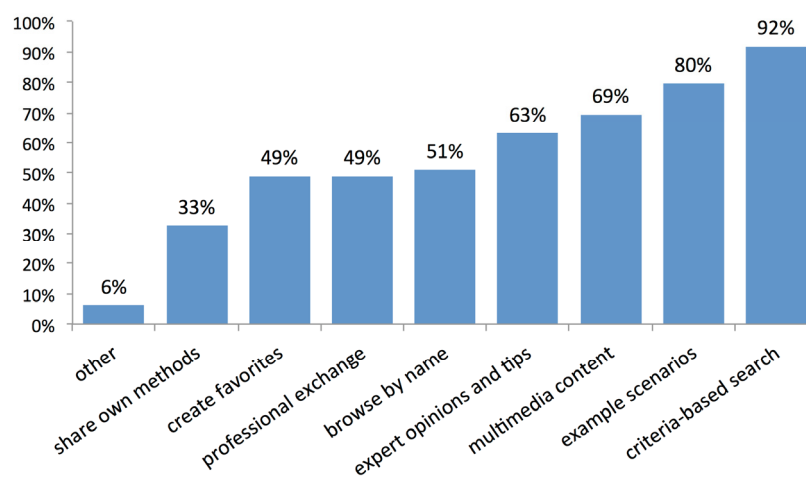
- They miss substantiated knowledge about which didactic methods exist.
- Subjects have too little experience in teaching and the appropriate use of didactic methods.
- The preparation time for courses and lectures is limited, especially for active researchers besides teaching.
- They lack feedback on the success of didactic methods; course preparation becomes a cost-benefit calculation (how much time to elaborate a new concept is it worth, if the benefit is unknown?).

Currently, teachers gather information about didactic methods through the internet, books, colleagues and advanced training courses. With MobiDics, we address the problems identified in the survey, as it provides the educational background of didactic methods, suggestions tailored to personal teaching needs, and feedback about successful methods usage from other lecturers, as well as from professionals (see also Möller et al., 2011a, 2011b; Meyer et al., 2012; Möller et al., 2012a, 2012b, 2012c). The fact that especially young people are potential MobiDics users adds to the long-lasting impact of our system.

4.2.4 Feedback on prototype

After watching the prototype demo video, 25% of smartphone users stated they would 'very likely' use the presented application, another 25% would use it 'likely'. This is in total 51% who answered in favour of MobiDics. 35% considered the usage rather unlikely, and 14% would definitely not use it.

Figure 4 Popularity of potential features in a mobile didactics toolbox with professors, lecturers, PhD students and teaching assistants. The target group is particularly interested in functionality that is not available through conventional information sources (see online version for colours)



The most popular features were criteria-based search (92% would use this), followed by examples (80%), multimedia explanations (69%) and expert knowledge (63%). For the full feature list, see Figure 4. These are particularly the features that are unique to a mobile didactics solution as MobiDics. Subjects are especially interested in functionality that goes beyond just a digitised version of a printed method catalogue.

5 MobiDics – concept and implementation

In Section 4 we have motivated a mobile learning app as an example for context-based university services and assessed the demand for such a tool in the target group. In the following, we describe the concept and implementation of the tool.

MobiDics supports the preparation, structuring and execution of university courses on mobile platforms. It is thereby an e-learning/m-learning system targeted at people involved in teaching, with the goal of increasing satisfaction with teachers and improving the quality of education (Möller et al., 2011a, 2011b; Meyer et al. 2012; Möller et al., 2012a, 2012b, 2012c). We here report on our iterative design of the initial prototype we have presented in our previous work. In the following, we will describe the didactic content, functionality and implementation of MobiDics.

5.1 Didactic methods

The learning content in MobiDics consists of a collection of didactic methods, which represent a classic link between didactic background concepts and the formulated educational goals in class. Well-considered use of specific didactic methods plays an important role in learning processes (Ramsden, 1992; Light et al., 2009). Such methods can, for example, activate students and contribute to more profound and sustainable learning experiences (Fink, 2003). At the university, where lessons and individual units are often longer and comprise more content than at schools, didactic methods have high relevance. They can support individual learning phases (e.g. knowledge transfer, repetition, assurance of understanding) and thus increase the effectiveness of university education.

The methods we consider have been provided by PROFiL¹¹, Sprachraum¹² and the Centre for Learning and Teaching in Higher Education (Carl-von-Linde-Akademie/ProLehre¹³) which are professional training institutions at Technische Universität München and Ludwig-Maximilians-Universität Munich. The MobiDics database currently contains about 50 didactic methods and is continuously growing.

Learning goals at the university often have a cognitive character. In order to apply the acquired knowledge, often additional social and affective goals are required (Fink, 2003). In MobiDics, didactic methods are organised based on ARIVA, a classification that supports multiple of these goals. The scheme has been developed at TU Zurich (Kiel, 2008 p.30) and classifies didactic methods according to the learning phase in which they can be applied. The ARIVA scheme comprises five phases:

- *Alignment* (German: Ausrichtung): Introduction and motivation of the learning content, creation of attention, match with the learner's world and experiences.
- *Reactivation* (German: Reaktivierung): Activation of previous knowledge to provide a link for embedding the new learning content.

- *Information* (German: Information): Active or passive knowledge acquisition, conveying of the learning content.
- *Processing* (German: Verarbeitung): Deeper, more extensive and reflective processing of the content, e.g. by answering additional questions, integrating the learned content in larger contexts.
- *Analysis* (German: Auswertung): Rehearsal of the learned content, answering of open questions that might have occurred in the processing phase, meta-analysis of the learning methodology.

In MobiDics, we combine these phases with different social forms, such as work in pairs, small groups of three/four/five people, discussion in the plenum (entire class), or didactic teaching (class is listening). The result is a two-dimensional matrix for method classification, e.g. group work methods suitable for the reactivation phase, or plenum methods for the analysis phase. Since each method already incorporates an educational goal through this classification, teachers can use them to create learning situations that are appropriate for their needs. At the same time, they create a sustained learning experience, as all methods are didactically well founded. Since methods also incorporate the form of cooperation of lecturer and students, as well as of students between each other, changes between social forms (e.g. alternating plenum and group work phases) support the maintenance of attention over longer periods of time. Learning settings can thereby be formalised along the structured dimensions of social form and learning phase, and can be reconstructed based on the building blocks in form of didactic methods.

5.2 Functionality

The features in MobiDics follow the four paradigms of Everywhere Use, Better Understanding, Context Sensitivity and Pervasive Cooperation (Möller et al., 2011a, 2011b; Meyer et al. 2012; Möller et al., 2012a, 2012b, 2012c). In more detail, the system supports the features described in the following.

5.2.1 Method management

The entire catalogue of didactic methods can be browsed by name, ratings, actuality, and frequency of use or relevance. Relevance is hereby calculated from both the number and recency of method access (similar to auto-complete suggestions in the browser address bar). The rankings do not only contain own usage statistics, but also incorporate data from other MobiDics users, so that users can see what methods are popular with peers. Methods can be rated and marked as favourites, so that every user can create their own collection of personally valuable methods for their own courses.

The didactic methods are available on the MobiDics server and synchronise with the client application. The entire content is, after the first synchronisation, also available locally and without active internet connection. This enables the entirely mobile use of the system also at areas without connectivity. All local changes are synchronised the next time when a connection is available, either WLAN or UMTS, based on the user's preferences.

Didactic methods comprise extensive descriptions of their appropriate and correct execution. They include examples and ideas for the practical implementation of the method ‘model’, tips from didactic experts and potential problems (e.g. what to do when students are not participating as intended). Besides the initial organisation along the dimensions of social form and learning phase according to the ARIVA scheme, each didactic method contains information on the ideal group size (is it suitable for larger lectures with 300 participants or only for smaller lab courses with 10 students?), the expected time needed, material that is required or optional (e.g. a flip chart, paper, a ball) and more. All this information is organised in searchable fields, enabling to perform very detailed searches using logical operators (AND, OR, NOT) and quantifiers (more than, less than). For example, it is easy to find methods for the reactivation phase, applicable for courses with more than 50 students that do not take more than 20 minutes.

5.2.2 *Explanations*

The usage of e-learning to communicate didactic methods enables a new level of explanations. Group work and games can be illustrated with animations and videos. Self-learning phases or group phases involving varying constellations of students can be simulated and evaluated on the device. MobiDics therefore contains a ‘gallery mode’ in which multimedia elements (images, videos, animations) as enhancements for the selected didactic method are available. Methods can additionally link to external resources such as Flash applications or interactive simulations to allow further look into the matter.

5.2.3 *Collaborative learning and exchange of experience*

Collaborative learning has been proven as effective in the ‘real world’, but is not yet naturally included in e-learning applications. We believe that learning from the experience of others is a central factor of learning success. The big advantage of e-learning is the simplicity to find people with similar interests or level of knowledge out of a large user basis, compared to a class where students often have different previous knowledge (especially in professional education). This is why we included a number of collaborative features to MobiDics, such as a community feature for peer exchange.

Users can share their own didactic methods and add them as new entries to the system. This user-generated content is then browsable and searchable just as the editorial content. The only difference is a small symbol that allows other users to identify such methods as user-generated content, since the quality and didactic success cannot be guaranteed. Still, we did not want to implement a quality control instance in form of an editorial team that continuously filters and checks new submissions before making them publicly available. The idea behind MobiDics is a platform to which every interested and committed person can contribute, be it the senior professor or the student tutor with only one year of experience.

Instead, we included a rating system that allows users to evaluate the quality of user-generated content themselves. A didactic method can receive a rating from 1 to 5 stars, which also influences the method order in the main screen when the sorting by rating is enabled. The rating is also used for the order of search results when methods would otherwise have the same level of adequacy. User ratings are thereby a democratic, implicit method of ‘pushing’ qualitatively high content to users.

Besides overall quality control, ratings have the function of determining the adequacy of methods for specific subjects and disciplines. Teachers will rate methods better when they used them successfully in their courses. Sure enough, people will rate methods not objectively, but according to their own perceived utility: A certain didactic method that is suitable for a social science seminar might not be appropriate for a math tutorial. A method suitable for a 20-person lab course might not be applicable in a computer science freshman lecture with 500 students. As a consequence, the social scientist will rate methods differently than the mathematician and the lab course tutor differently than the professor.

We see this subjectivity of ratings as an additional chance for MobiDics. The old problem of learning didactic methods with books is that they are generic. In particular less experienced tutors will be uncertain whether a described method is actually applicable for their subject and teaching situation. MobiDics partly solves this problem already with the filter search, which allows limiting method choices to learning settings, such as 'lab course with less than 20 participants'. Ratings in combination with a search filter on disciplines now even allow verifying the adequacy for one's own subject: All users who rate a method have a user profile in which they specified their discipline. That way, MobiDics can use statistical information on ratings to find out the amount of ratings of a certain subject, faculty, or scientific direction (e.g. life sciences, engineering, and social sciences). The information that most people who rated a didactic method with more than 3 stars were engineers tells with certain reliability that this didactic method is suitable for engineering courses.

As an additional step on top of the user-generated content and rating system, we added a function for commenting methods. Besides the anonymous, fixed-scale ratings, users can report on their experiences with a specific method in detail using a free text field. This opens up the space for discussion and exchange. Teachers can not only describe the effectiveness of a method in a specific context of use, but also directly address problems and potential solutions. The feedback of colleagues and peers can likewise bear great potential, since they have probably experienced similar problems in their own courses and can now share their advice. Last but not least, didactic professionals can hook into the discussion and provide their professional view or provide additional tips and tricks. Users can reply on particular comments, creating a nested structure similar to a discussion board. Comments can, again, be rated with 'thumbs up' or 'thumbs down' symbol. The ratings can help users to quickly estimate how the quality of a comment was perceived by other users. Besides sorting comments by date, ratings can be used to show high-quality comments on top.

Besides the public sharing of methods, users can also decide to keep their newly added methods private. This allows using MobiDics as a personal, privacy-sensitive, readily available toolbox of methods with all advantages of digital search and presence in the pocket.

5.2.4 Context-sensitive integration in teaching and learning environments

With MobiDics, the user can quickly react on context-specific conditions, such as the room size and equipment. In case of unexpected changes of the room or broken or missing equipment, didactic concepts might have to be revised. For example, the prepared didactic method could require a whiteboard, which is not available in the current lecture hall. The search function in MobiDics allows dynamic re-planning of methodical concepts based on the room context.

MobiDics also supports the integration in existing teaching and learning environments such as room management and reservation systems (e.g. TUMOnline¹⁴ at our university). Such databases contain information on room sizes, equipment (e.g. whether chairs can be moved around for group work or whether the room has fixed rows), as well as lecture plans (when does which lecture take place in which room). By an interface to this database, MobiDics can dynamically adapt its content to the available facilities for a planned lecture and context-sensitively react on e.g. room changes. Moreover, MobiDics can retrieve a location estimate from the phone platform's location provider, so that it can be coupled with an indoor localisation service or other location providers implemented on the smartphone.

5.2.5 *Multilingualism*

MobiDics is designed to support multiple languages seamlessly within one system. The need for multiple languages emerges not only from the fact that many universities offer courses in different languages (e.g. German and English at our university), but also because didactic content is managed best in the original language it has been developed for. Wordings and concepts are often difficult to translate and known under their original terms in the didactic community.

MobiDics users maintain a list of their preferred languages that determines the order in which multilingual content is selected and presented in the user interface. Let us assume a user's preference list is 'English, German, Spanish'. In that case, for a method available in English and German, the English translation would show up, while a method available in German and Spanish would show up in German. A method only available in French would not be listed at all. Users can add translations to methods by selecting a language in which the method is not described yet. Numeric fields (such as group size, estimated time, etc.) are automatically copied to the new language, only the translations of the textual fields have to be added.

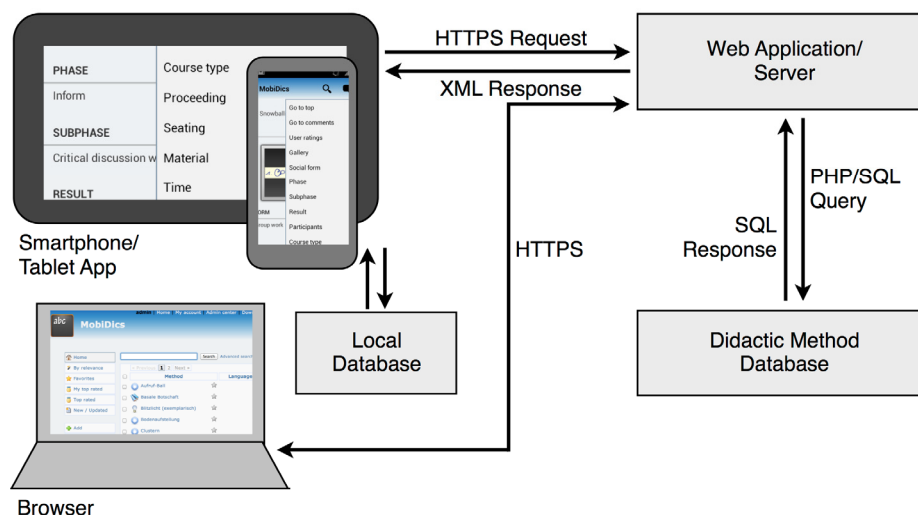
5.2.6 *User management*

Every user of MobiDics creates an account with a nick name and additional optional information, such as age, profession (PhD student, tutor, professor, lecturer, ...), discipline, courses teaching, experience, etc. This additional information is helpful for estimating the relevance of a user's contribution in search queries. For example, the profession of a user who rated a method can be an indicator for the appropriateness in one's own course, or the comment of an experienced professor might be especially valuable. Users can choose which fields are publicly visible to others to keep their desired level of privacy. This shall encourage e.g. newly appointed faculty members to use the app without the colleagues knowing this and thereby lower the border to use didactic methods in their lectures.

5.3 *Implementation*

The MobiDics infrastructure consists of a server, a web interface and a mobile client application, which are illustrated in Figure 5.

Figure 5 A schematic overview of the MobiDics infrastructure. MobiDics consists of a mobile Android application and a web interface, which both synchronise with the web server and database of didactic methods in the background (see online version for colours)



5.3.1 Server

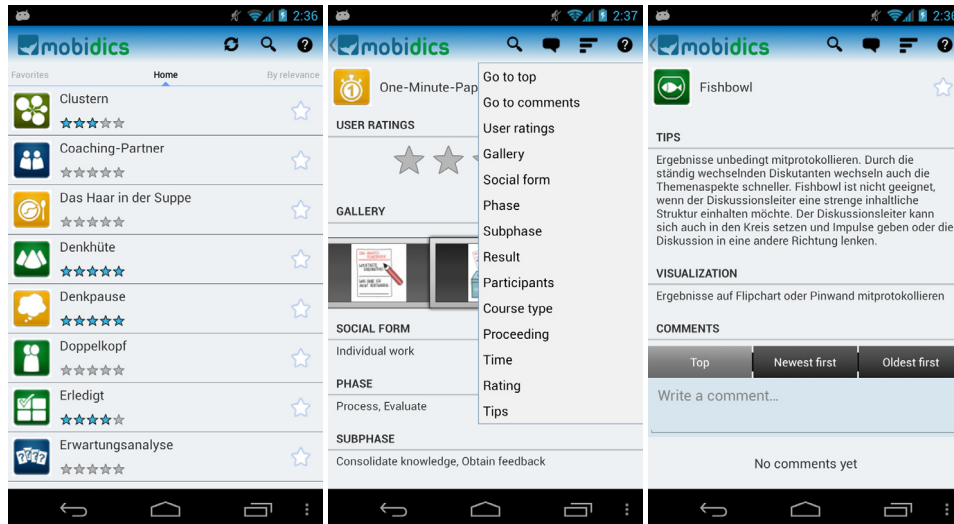
A SQL database holds all methods that are currently available to the system and manages their appearance on user's devices based on language flags and access control performed quickly in a large amount of data. The server also manages the user account system. Each time a user starts the local MobiDics application or logs into the web interface, she is authenticated with the server and potential changes are synchronised.

Synchronisation works in two directions: both new methods and comments are downloaded to the client, and local changes are uploaded to the server and delivered to other users. When the client application is used offline, the last synchronised state from a local database is used (a previous authentication must however have been successful to prevent unauthorised access). Changes are then transmitted on the next login. A XML (Extended Markup Language)-based data format is used to exchange information with the server and the mobile application. For all traffic between clients and the server a secure connection (Hypertext Transfer Protocol Secure, HTTPS) is used.

5.3.2 Client – mobile app

The client application is programmed in Android, thereby supporting a wide variety and a large heterogeneity of devices (smartphones, tablets of different sizes). The user interface is automatically adapted to different screen sizes and ratios for optimal use of the available space. The client implements the platform-typical interaction paradigms such as gesture-based navigation (using a swipe to switch between methods), pinch to zoom, context-sensitive action bar menus etc. for a quick learning curve when interacting with the application and 'feeling at home'. An incremental search shows results already while typing. Besides automatic content update through synchronisation, also the application itself is updated automatically so that entirely new features can be added. The screenshots in Figure 6 illustrate the user interface.

Figure 6 Screenshots of the mobile application. Left: the main menu of didactic methods, sorted by 'recently viewed'. Middle: the method description view with jump list to different sections. Right: the commenting function for methods (see online version for colours)



5.3.3 Client – Web interface

The entire functionality of MobiDics is also available in a web application implemented with AJAX. The interface available in the browser allows a more comfortable navigation in non-mobile settings, e.g. in the office or at home, and provides more screen space. It is also the convenient way to enter longer portions of text, e.g. for commenting on methods or uploading own content. The web application communicates with the database using PHP and SQL. The screenshots in Figure 7 illustrate the user interface.

Figure 7 Screenshots of the web interface. (a): the main menu of didactic methods (with language indicators); (b): the detailed description page of a method with multimedia content, such as images or sketches (see online version for colours)



Figure 7 Screenshots of the web interface. (a): the main menu of didactic methods (with language indicators); (b): the detailed description page of a method with multimedia content, such as images or sketches (continued) (see online version for colours)



6 Future perspective of MobiDics: variation of the method-box systematisation

Observations at the Academic Training Centre show that lecturers like the idea of adding variety to their courses with interactive teaching methods and they would like to know a lot about methods, while at the same time some lecturers are still afraid to apply them in their courses. Why are some lecturers afraid of using teaching methods and how can the MobiDics toolbox support lecturers to realise what they like about methods? To find out the reasons for the discrepancy some lecturers feel, liking but not using methods, lecturers have been asked about their needs in a survey on 'teaching at university'. The qualitative survey consisted of two parts. First we asked what lecturers consider to be a good teaching course and second we inquired their concerns about lecturing. We had 47 participants, recruited from the Academic Training Centre at the LMU, TUM, and other universities in Bavaria. The average age was 32.6 years (standard deviation 8.5), from 24 different faculties, a mix of natural science and humanities, and their teaching experience ranged from novices to 10 years of teaching experience. For the results, we clustered the answers and then categorised and ranked them by their number of counts, starting with the most frequently mentioned category.

6.1 Results of the study

In Table 1, the five most frequently mentioned categories of the qualitative survey Good teaching course are listed and explained with different examples.

Most of the answers the lecturers gave (46 answers) belong to the category 'Didactic concepts/teaching methods'. This is followed by the categories 'Motivation' (36 answers) and 'Impart/Communication of Knowledge' (31 answers). The fourth and fifth most mentioned answers belong to the categories 'Reaction/Response to Students' (24 answers) and 'Structure/Organisation' (21 answers).

Table 1 Examples of categories mentioned in the qualitative survey (*Good Teaching* course)

<i>Category</i>	<i>Counts</i>	<i>Examples</i>
Didactic concepts/teaching methods	46	'When the classes don't follow the same structure all the time' 'Dynamics and flexibility regarding the teaching and learning process' 'Interesting and rich in variety' 'Interactive' 'Not only frontal talk, participation of students is requested'
Motivation	36	'The teacher is motivated and knows how to motivate the student' 'A teacher who is enthusiastic about his own subject' 'Activating the students' 'Arouse interest' 'Time flies by'
Impart/Communication of Knowledge	31	'Students learn something' 'Long-term communication of knowledge' 'Teaching students to question things/take different perspectives' 'Foster independent thinking' 'Students can use and reflect theoretical knowledge'
Reaction/Response to Students	24	'The student feels his wishes and needs recognised and dares to ask questions and make mistakes' 'Teacher interacts with students' 'Realise what's going on with the students'
Structure and Organisation	21	'Clear, but not too inflexible concept' 'Goal-oriented, transparent structure' 'Structured and well prepared'

Table 2 Examples of mentioned concerns about lecturing

<i>Category</i>	<i>Counts</i>	<i>Examples</i>
Competence/Be professional	26	'Nervousness' 'If the level of knowledge of the students is appropriate to the level of the course' 'That I lose the golden thread'
Motivation/Enthusiasm	24	'Will I be able to motivate' 'That students are unmotivated' 'Participants are bored' 'Students engage in other activities during the seminar, e.g. mobile phone, e-mails...'
Reaction/Response to Students	10	'Not being considerate of the students' 'Questions are not clear and inconsiderately asked on my part' 'That I don't do justice to some students/ questions'
Collaboration	8	'That students don't participate' 'Students don't read their texts and are not prepared' 'Silence when discussion is wanted and I give my best'
'Being liked'	8	'Will I be taken seriously if I do things differently from my colleagues – reduce hierarchy etc.' 'Students have high expectations and complain' 'My role as teacher – am I too strict/easygoing'

In Table 2, the four most frequently mentioned categories of the qualitative survey Concerns about lecturing are listed and explained with different examples.

Most of the answers the lecturers gave belong to the categories ‘Competence/Be Professional’ (26 answers) and ‘Motivation/Enthusiasm’ (25 answers). They are followed by the categories ‘Reaction/Response to Students’ (10 answers), ‘Collaboration’ (8 answers) and ‘Being liked’ (8 answers).

6.2 Discussion and future perspective

First of all, it is interesting to see that lecturers see didactic concepts and teaching methods as a very important aspect for good teaching. That confirms our observation that lecturers like to know a lot about methods. Teaching methods, like discussion methods or well-structured methods for the independent work of students for example, are not only helpful to have interactive lectures, but also to impart knowledge (category 3), to help students reflect on the theoretical knowledge or to foster independent thinking respectively.

In almost all categories representing a good teaching course, the desire for a flexible, dynamic, student-oriented and student-motivating way of teaching is expressed – thus the desire to use different teaching methods. MobiDics is therefore a good and supportive toolbox to learn a variety of teaching methods, with regard to the individual teaching situation.

Beside the huge list of aspects which make up a good teaching course, there are a lot of aspects lecturers are afraid of in their courses. In other words, the lecturers have other needs which have to be fulfilled before they can think of applying teaching methods. Most of these aspects belong to the categories ‘Competence/Be Professional’ and ‘Motivation/Enthusiasm’. Some lecturers, for example, think that they cannot impart knowledge in a well-structured or competent way. Furthermore they feel insecure in dealing with heterogeneous groups of students which have different levels of prior knowledge. Most concerns lecturers have (in all categories), are along the line of them feeling insecure about the participation or attention of the students. Even if they like interactive teaching methods, some lecturers would rather have no interactive parts in their courses (so prepare and hold the course almost completely teacher-centred) than not knowing whether the group of students will participate or not.

Now, how can teaching methods respond to these concerns or needs lectures have? All teaching methods include a specific teaching goal e.g. support exchange (like discussion methods), inquire existing knowledge (like a question round), repeat contents (like interactive mind map) or activate students (like quiz). Besides that, all methods can be modified, so that the method can be applied to all participants or small group works (compare social forms). If a lecturer would, for example, like to support the exchange, but he is afraid of an exchange among all students, because there could be less participation, then he might not use a teaching method. But if he finds the appropriate method, like an exchange in small groups, he might apply the method, thus including an interactive part in the course with which the students can reflect the content more intensively. This example shows that teaching methods can help with concerns lecturers have with applying different methods.

To finally answer the question how the toolbox MobiDics can help lecturers, we present the following future perspective. A way to assist lecturers, not only to find appropriate methods, but also to use them, is to offer them a different access to these

methods. At the moment, teaching methods in MobiDics are organised based on ARIVA and social forms. This matrix helps lecturers find methods that fit best, based on their individual teaching situation. The idea now is to add a new access that combines the teaching situation of the lecturers and their needs/concerns – something which was not yet taken into account by any teaching method systematisation. For the future, this means that lecturers who feel sure about applying methods can either choose the direct way to the method systematisation, that is through AVIVA and social forms. Or lecturers can first indicate their needs / concerns and then receive a suggestion of various teaching methods. This twofold access should support lecturers in applying different methods.

7 Discussion, outlook and future work

In this article, we reported on our iterative development on MobiDics, a mobile learning tool for didactic training. In an initial survey, we collected data on current and potential future use of university services. On this basis, we developed the concept of MobiDics as an example for a mobile, context-based application for learning environments and evaluated it in a two-step process. An initial prototype was evaluated online based on a video review (Möller et al., 2011a, 2011b; Meyer et al., 2012; Möller et al., 2012a, 2012b, 2012c). We used this assessment for first feedback and estimation whether users would adopt the system. From the 103 users who saw the video demonstration and owned a smartphone, 51% declared that they would use MobiDics themselves ‘likely’ or ‘very likely’. Asked for most appealing features, people named the criteria-based search (92%), illustrative multimedia examples (80%) and expert knowledge (63%). People here mentioned particularly features that are not available in traditional information sources. In a second step, the subsequent iteration of the system (as described in this paper) was informally evaluated by a group of users from the target group. Here, particularly the rating function and the ability to comment methods and contributions of others were highly appreciated.

We are aware that MobiDics lives from its users and their social interaction within the system. In future work, we are planning to conduct a long-term evaluation in the field. Observations and user feedback how the interactive tools of MobiDics (ratings, discussions, new method contributions) are used will hopefully help us to adjust the system to users’ needs. In particular, we strive to understand which learning processes MobiDics sets in motion through synergies and collaboration between peers. We are also interested in quantitative measurements of improvements of teachers’ satisfaction. Another scientific goal is a theoretical formalisation of how didactic methods can be classified. The present version of MobiDics already integrates alternative names for methods. In the next step, differently described but similar methods should be matched to one and the same method entry (comparable to an alias). Subsequently, we aim to generalise this problem and deduce similarity models for methods, which could then better be matched with the user’s profile and interests.

We plan to conduct a long-term study with a larger number of people from different disciplines to gather more insights on the usage and acceptance of the current prototype and to identify future improvements for a release of MobiDics.

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Notes

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