Towards mobile-centered authentic, personalized and collaborative assignments in engineering education

TOWARDS MOBILE-CENTERED AUTHENTIC, PERSONALIZED AND COLLABORATIVE ASSIGNMENTS IN ENGINEERING EDUCATION

Mara Saeli, Zeger-Jan Kock, Alexander Schüler-Meyer, Birgit Pepin
Eindhoven University of Technology, Eindhoven, The Netherlands

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ABSTRACT

The last decade has seen a significant rise in the use of mobiles devices, such as smartphones, tablets, or laptops in all areas of society. Professionally, engineers collaborate with partners all over the world and this is made possible by mobile technology. In tertiary education, students learn in different settings, in and out of campus, in the train or at a café. Researchers have identified new possibilities for teaching and learning, afforded by the use of mobile technologies (and termed ‘mobile learning’; ML). They claim that ML may (1) facilitate learning, formally or informally, in a place, at a time, and in a way preferred by students, (2) help students to become engaged in tasks that resemble authentic tasks in the workplace, and (3) facilitate student cooperation and collaboration. In this paper we present the first results of an ongoing project which aims to design and evaluate – for different engineering disciplines – prototypical ML assignments. We report on the results of a survey carried out at a Dutch University on the current use of and attitudes towards ML from both the instructors’ and the students’ perspectives. The results show that in various faculties at the university ML initiatives have been introduced in education and that there is a basis to create further opportunities for active student learning. We also present an outlook on the next stage of the project: the design of prototypical student activities from the respective engineering disciplines of the project partners: Mathematics, Physics and Built-Environment.

1 INTRODUCTION

1.1 Mobile Learning and Authenticity

The use of mobile devices, such as smartphones, tablets, or laptops has been widespread in the private, professional, and educational areas of society. In developed societies, most members of the population routinely use mobile devices. For example, in 2018, 86% of the Dutch population used a mobile device to access the internet outside of home or the workplace, according to the national statistical office Statistics Netherlands (CBS); the European Union average was 69 percent [1]. Recent events have shown how mobile and online learning becomes vital when unexpected events such as lockdowns happen. In the last months teachers and lecturers across the globe have been faced with the immediate need to digitalise their teaching material and provide online resources for their students. Even before this rapid shift towards online education, researchers have identified new possibilities for teaching and learning, afforded by the use of mobile technologies. Mobile technologies may (1) facilitate learning, formally or informally, in a place, at a time, and in a way preferred by students, (2) help students to become engaged in tasks that resemble authentic tasks in the workplace, and (3) facilitate student cooperation and collaboration [2]. Mobile learning might also have negative effects, such as heavy cognitive load caused by an improper learning design [3].

The use of mobile devices in education has been termed ‘mobile learning’ (ML) or ‘m-learning’, defined by El-Hussein and Cronje [4] as ‘any type of learning that takes place in learning environments and spaces that take account of the mobility of technology, mobility of learners and mobility of learning’ (p. 20). The definition emphasizes that ML is more than learning supported by mobile technology. Devices that fall under the umbrella of ML are for example mobile phones, tablets and modern laptops, which comply with the authenticity, personalisation and collaboration facets, allowing students to use them at a time and space (train, café, etc.) of their choice. Here, mobile phones and tablets are in focus because of their innovative use cases.

In this paper we present the first results of a survey carried out at a Dutch University of Technology on the current use of and attitudes towards ML from both the instructors’ and the students’ perspectives. The survey is part of an ongoing project started in 2019 entitled “Mobile learning for challenge-based education – Enhancing engineering education with mobile-centred authentic, personalized and collaborative assignments”. The project goals are to design and evaluate prototypical mobile-learning assignments in different engineering disciplines, which can be implemented in an authentic way through mobile technology.

To prepare the design of ML activities in different engineering disciplines, knowledge is needed about the current use of and attitudes towards ML. Hence, to better understand the current use of mobile technologies for learning, the following research questions were investigated:

RQ1: What are the attitudes, experiences, and ideas of university experts of the respective engineering disciplines regarding the use mobile technology in their teaching and in their research?

RQ2: How do students perceive the use of mobile technology for learning?

We first describe the analytical framework for ML, using the socio-cultural approach of the iPAC model (with PAC standing for Personalisation, Authenticity and Collaboration) and then present the results of the surveys.

1.2 Theoretical Background

The central tenet of ML is that it blurs the traditional time and space boundaries of traditional classroom learning (e.g. a fixed timetable and a specific classroom). As traditional time and space boundaries are dissolved, ML can be implemented at times convenient to the learner and in relevant (real or even virtual) contexts. Based on the socio-cultural notions that learning is situated, facilitated by social interaction, and mediated through the use of tools, this tenet led to a mobile learning framework [2] which illustrates the three central facets of mobile learning. The three distinctive facets of ML are authenticity, personalization and collaboration (Figure 1; [5]).

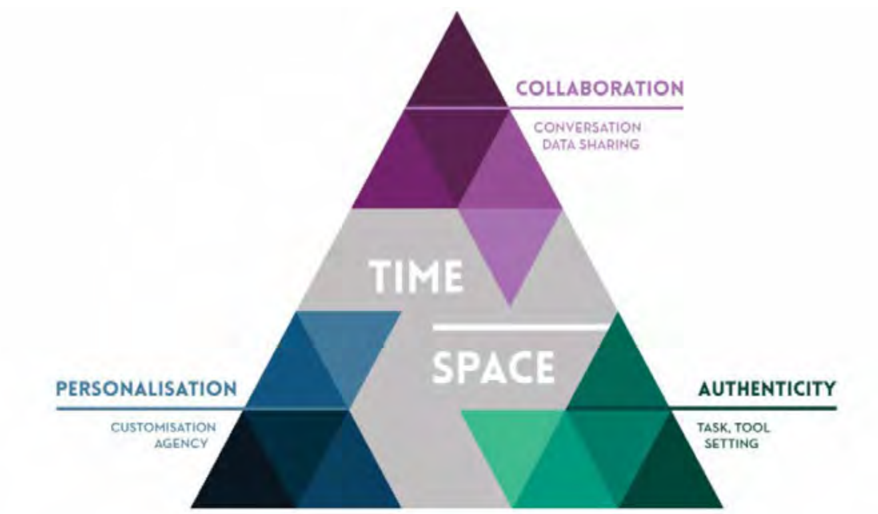

Figure 1 - iPAC framework [5]

Authentic learning activities utilize real-world situations and problems. In that way they allow students to develop competences in the context/s in which these competences will later be used. It has been argued that authentic learning is essential to make learning genuinely meaningful for the student, as all knowledge and skills derive their meaning from the authentic context [6]. In the iPAC framework, ML may foster authenticity through (a) the task (the extent to which it resembles tasks of real-world practitioners), (b) the setting (virtually or physically authentic), and (c) the digital tools used (resembling the tools used by real-world practitioners).

The *personalisation* facet of ML is subdivided into two related subscales: agency and customisation [2]. Agency refers to the level of control and ownership the learner has with respect to the learning process. This includes, for example, the possibility for students to choose their own lines of inquiry, and follow their own interest [7]. Customization may take place at the tool level (i.e. personalisation of the mobile device, selection of tools) and at the task level (student control over the place, pace and time of learning). The personalization facet of ML fosters student autonomy, which under the right conditions may contribute to motivation [8].

Mobile technology facilitates interaction and *collaboration* as it enables students to contact peers, teachers, and experts, informally or supported/encouraged by the learning environment [9]. From a socio-cultural perspective, forms of interaction are essential for learning. ML facilitates interaction, as documents, sensor data, pictures and videos, and other resources can easily be shared through mobile connections, and be used by other learners. Accordingly, the collaboration feature of the ML framework distinguishes the subthemes conversation and data sharing [2].

The iPAC framework shows the potential of ML for learning. However, we do not know to what extent the actual use of mobile technology at our University allows this potential to be realized. Therefore we studied how mobile technology has been used by the university teachers for teaching and research, and by the students for learning, and what their attitudes towards mobile technologies in the context of learning and teaching are.

2 METHODOLOGY

To answer the research questions, we used the following data collection strategies:

2.1 A survey administered to all university teaching staff (RQ 1).

An email was sent to 1009 university staff involved in teaching (including professors, associate professors and PhD candidates who are involved in both teaching and research) with an invitation and a link to the survey. We received n=84 usable responses.

The core items of the survey asked respondents about their experiences and ideas related to the use of mobile technologies for research, engineering practice, and in the engineering education of their respective disciplines. Respondents also had the opportunity to state reservations they had regarding the use of mobile technology in education. A mobile device in the context of the surveys was a smartphone, tablet, smartwatch, or other general-purpose small portable device. We did not include laptops, as we expected them to be routinely used in research, engineering and learning. The survey consisted of 14 items.

Answers to the open survey items were (non-uniquely) coded, and the codes were categorized as ideas for: engineering practices and research (authentic practices); educational organization and enactment (personalization and collaboration); reservations on ML general comments.

2.2 Follow-up interviews with selected university teaching staff (RQ 1)

Selected participants from the university staff were interviewed. The selection of participants was made from the respondents who gave their email address in the survey. The selection was based on two criteria: (1) to involve different university departments, and (2) to select respondents whose survey responses provided specific ideas regarding ML. We contacted eight survey respondents from different departments, five of whom gave permission for an interview, from the departments of Applied Physics (also connected to Mechanical Engineering and Electrical Engineering), Chemical Engineering, Applied Mathematics, Electrical Engineering and Built Environment. In the interviews we asked in more detail about the present uses of mobile technologies in research, engineering practice and education, and about ideas for future use. The interviews were transcribed and coded to find current uses of mobile technology in research, engineering practice and learning at the university, and to find opportunities for ML that can be developed into a prototype.

2.3 A survey administered to all TU/e bachelor students (RQ2).

An email was sent to the TU/e bachelor students with an invitation and a link to the survey (6108 students). We received n=486 responses complete enough to be used in the analysis. The survey consisted of 14 items, with several sub-items, including: student background information; the Integrated Communications Technology Learning scales [ICTL; [10]]; the use of mobile technology for learning and for private matters.

In the analysis of the surveys we used descriptive statistics and coding of the open items.

3 RESULTS

3.1 University teaching staff survey and interviews

The survey results showed for which purposes in the field of research/engineering of the respondents mobile devices were more/less important. The majority of respondents considered mobile devices to some degree important to find information, to communicate, to collaborate, to make/share pictures, as well as audio/video recordings, and to use particular apps. The majority of respondents did not consider the use of mobile devices important for the purposes of dissemination (e.g. of research results), joint work on documents or designs, data collection (e.g. using mobile device sensors), using locally specific information (e.g. augmented reality) and virtual reality. We found differences between departments on the importance of mobile devices for particular purposes. For example, respondents of the department Built Environment considered the use of mobile devices generally more important for practice/research than members of the other departments. In particular this was the case for the purposes of data collection, obtaining locally specific information, and virtual reality. The departments of Mechanical Engineering and Electrical Engineering considered mobile technology less important, except for the purposes of “making pictures, videos and audio recordings”.

The university (associate) professors interviewed generally had a positive attitude towards the use of ML, as indicated by the following two citations:

"If students use their mobile anyway during lectures (…) you may just as well make sure they use it for the lecture", and
"There are advantages in bringing (student) projects from the lab closer to reality and I notice that the recent generation of students really likes that".

The responses to the teaching staff survey and the follow-up interviews resulted in a list of experiences and ideas on the use of mobile technologies for research, engineering practice, and in engineering education, as well as reservations regarding this use. A summary of the findings, categorized as "established", "emerging" and "reservations", is shown in Table 1. Established practices were those that have been encountered routinely in (tertiary) education. Emerging practices have been used by one or a few respondents (e.g. in research or practice), have not been used routinely in (tertiary) education, and required technical and/or educational development work. Be reminded, these responses reflect the situation before the Covid-19 lockdown.

Table 1. Summary of university teachers' experiences and ideas

	Established practices	**Emerging practices**	**Reservations**
Research	Documenting research work (journals, camera). Location-based services and information at the site of interest. Collaboration and communication.	Complex data collections about humans (mobility patterns). Various forms of data collection, e.g. using cheap sensors.	
Teaching	Accessing information. Submission of student work. Apps to make teaching more interactive. Collaboration and communication. Recording lectures.	Apps that allow to explore/simulate inaccessible phenomena. Integration with tools to replicate scientific practices. Interactive course materials. Student assessment. Tools to organize self-directed learning.	Lack of evidence about learning benefits in large scale studies. Distraction. Facilitate understanding, not and end in itself. Maintenance of infrastructure. Does not replace face-to-face interactions.

3.2 Student survey

The ICTL part of the survey contained a scale on *Information seeking*, a scale on *Information sharing* and a scale on *classroom learning* [11]. We did not use the classroom learning scale, due to its low reliability (Cronbach's alpha 0.43). The other scales showed acceptable reliabilities (Cronbach's alpha 0.66 and 0.77 respectively).

Table 2. Mean of ICTL scales (N=485)

Scale	Mean (1-4)	SD
Information seeking	3.26	0.49
Information sharing	2.54	0.65

Table 2 shows the mean values for the two scales. A comparison of the means indicates that students' attitudes towards online information seeking is more positive than towards information sharing (Related-Samples Wilcoxon Signed Rank Text, p=0.000).

To compare students with high and students with low scores on the ICTL items, a k-means cluster analysis with two clusters was conducted on the ICTL items in the "Information seeking" and "information sharing" scales (detailed in Table 3). We found a cluster of students with a relatively high mean ICTL score (indicating a positive attitude towards information seeking and information sharing; 54% of respondents) and a cluster with a relatively low mean ICTL score (indicating a less positive attitude, in particular towards information sharing; 46% of respondents). In the group with the positive attitude male students were overrepresented; students in this group on average used more mobile devices, used them more often, and used them more for study related activities than students in the group with the less positive attitude. We identified some differences between students from different departments (e.g. computer science respondents in majority belonged to the group with the positive attitude, while chemical engineering respondents in majority belonged to the group with the less positive attitude).

Table 3. Comparison of students with high (cluster 1) and low (cluster 2) mean ICTL scores

	Cluster	
	1. Higher ICTL	2. Lower ICTL
N	255 (54%)	221 (46%)
Information Seeking[a] (1-4); M (SD)	3.49 (0.37)	3.00 (0.47)
Information Sharing[a] (1-4); M (SD)	3.01 (0.43)	2.01 (0.40)
Male[c]	182 (59%)	128 (41%)
Female[c]	73 (45%)	91 (55%)
Estimated hours spent daily using a mobile device; M (SD)		
In own time[b]	3.0 (1.6)	2.7 (1.7)
At university for studies[b]	1.0 (1.0)	0.73 (0.85)
At university for private matters[b]	1.4 (1.3)	1.2 (0.9)
I use my mobile device to study		
Where I want[a] (1-4); M (SD)	3.1 [a] (1.0)	2.8 [a] (1.1)
When I want[a] (1-4); M (SD)	3.0 [a] (1.1)	2.7 [a] (1.1)
How I want[a] (1-4); M (SD)	3.3 [a] (0.9)	2.8 [a] (1.1)

Notes: [a]: p<0.01; [b]: p<0.05; independent samples t-test

[c]: There was a significant association between gender and cluster $\chi^2=8.70$, $p<0.01$. This indicates that, based on the odds ratio, the odds of being in cluster 1 is 1.77 times higher for male students than for female students.

We also asked students for examples on the use of mobile devices in university courses and non-exclusively categorized the responses. Table 4 shows how often students mentioned examples from the different categories. It highlights that the use of mobile devices for communication and the use of apps provided by the university are by far the most common used of mobile devices by students for their courses.

Table 4. Examples of student use of mobile devices for university courses

Category of use	Percentage of students
Communication (e.g. Whatsapp, email)	80.8%
Apps provided by the university	23.8%
Looking for web based information (e.g. Wikipedia) Collaboration on projects and group work Quizzes during lectures Course relevant videos and videolectures Calculators and maths apps	< 10%
Note taking / agenda / to do list Using course specific apps Share documents Take pictures / record videos Making use of buit-in sensors	< 5%

4 SUMMARY

We found that in various departments of the university ML initiatives have already been introduced in education. In particular, students have used mobile devices to access information, and teachers have used ML to make their lectures more interactive. The potential to develop ML could be found in the introduction of more authentic tasks and challenges and in more sophisticated ways to personalize the learning experience. In particular, some ML research practices identified in the study could be a foundation to design research-baed learning activities that utlize ML.

Our respondents do not constitute a representative sample of the university staff and students. Nevertheless, the attitudes of the TU/e staff and student respondents towards ML provide an solid foundation to start designing and testing ML tasks. The results suggest that in the design of ML learning activities one should take into account that there are reservations and that not all students shared the same positive attitude towards ML. Therefore, the added value of any ML learning activity for didactical and educational purposes needs to be transparent to both teachers and the students.

For the next steps of the project – developing and testing prototypes (2020-2021) – we have selected three use cases for further development from the ideas and suggestions we received. They will be developed, tested and evaluated in the following phases of the project. These cases are:

1. ML student preparation for a 3D virtual laser lab (Applied Physics);
2. Interactive mobile-optimized consolidation tasks on Linear Algebra (Applied Mathematics);
3. A mobile app in combination with student tasks to collect and analyze localized data (Built Environment).

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