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Effective interventions for systematic use of mobile learning in an integrated science and math learning process

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1. Introduction

The number of mobile devices in the hands of students is increasing rapidly, but according to a survey held in Estonian schools among sixth and ninth grade students, less than 5% of students use mobile devices actively in learning processes in a science and mathematics context (Pedaste et al., 2017a). In a meta-analysis, conducted by Sung, Chang, & Liu (2016), it can be seen that there has been many successful attempts to include mobile devices in learning activities. However, the authors also conclude that, although the effects of using mobile devices in learning process are even higher than using computers, there is a need for a framework to describe comprehensively how to use mobile learning in a way that it is most beneficial from the educational perspective.

> Mobile learning or mLearning, which is described by Martin and Ertzberger (2013) as: "[...] learning that occurs when learners have access to information anytime and anywhere via mobile technologies to perform authentic activities in the context of their learning." (p. 77)

has many advantages, such as portability, enabling constant access to information, attractiveness to the new age group (Hashemi et al., 2011), means for collaborative learning and creating common interpretations (Nyiri, 2002; Sharples et al., 2007), as well as providing competition, challenge and offering immediate feedback, which is a great tool to keep students working even for difficult problems (Ciampa, Gallagher, 2013; Geddes, 2004).

Researchers have also identified negative aspects of mobile learning, such as potential heavy cognitive load (result of improper learning design) (Hui-Chun, 2014), limited screen size (Hashemi et al., 2011; Cavus, Ozdamli, 2011) and a lack of a cross-platform makes it hard to create contents for all types of devices (Hashemi et al., 2011). It is arguable, if the advantages of mobile learning outweigh the disadvantages, but in the situation at hand, where more and more students own a mobile device and using them in the learning process seems to be appealing to them, it is justified to try and address serious problems in education with the help of mobile learning.

The specific problem addressed in the current thesis is students' low motivation and achievement in learning science and mathematics. Science and mathematics lessons are often uninteresting and non-relevant for students (Potvin & Hasni, 2014; Sjoberg & Schneider, 2010). Students also do not see school science as useful for their lives and future developments, since there seems to be much repetition and too little challenge (Osborne & Collins, 2001; Abel & Lederman, 2007). Moreover, international studies such as PISA and TIMSS show that adolescents, in developed countries (including Estonia), have especially low motivation towards learning chemistry and physics (Teppo & Rannikmäe, 2008). Even students with high cognitive potential for science do not pursue a career as scientists, because they lose their interest at school (Krapp & Prenzel, 2011). As a result, students' low motivation is causing a serious problem in the European Union – as young people do not pursue a career as scientists, STEM-professionals are gradually becoming elder. More than 50% of STEM-professionals (and related professionals) in the European Union are at a senior age (European Commission, 2015).

One way to make studying for students more relevant and interesting is bringing more student-centered learning approaches to the classroom. Inquiry-based instruction is one of the most recommended teaching method in the science classroom (DeBoer, 1991). However, planning and conducting inquiry-based learning can be time-consuming and often difficult for teachers, so we argue that it may be reasonable to use the help of technology – to give teachers a tool for using students' or schools' devices in learning in a way that would improve students' inquiry skills. Inquiry skills are for example formulating questions, generating hypotheses, exploring theories, planning experiments, conducting experiments, interpreting data and drawing conclusions (Pedaste et al., 2015). As research conducted in Estonian schools shows, students struggle the most with formulating hypotheses and research questions and also with planning experiments (Pedaste et al., 2017b), it is useful design learning activities which in addition to increasing students' motivation, focus also on enhancing their skills of formulating hypotheses and research questions and planning experiments.

Taking all the above into account, there is a need for a framework of how to use mobile devices in science and math subjects in order to increase students' motivation and improve their skills in hypothesis and research questions development and experiment planning.

According to Deci, Vallerand, Pelletier and Ryan (1991), students' intrinsic motivation is related to three aspects: students' perceived competence, which is increased by better performance feedback and choosing optimal challenges for each student; perceived relatedness, which becomes stronger when the student is accepted by peers and feels like he or she belongs to a group or society; perceived autonomy, what can be increased with offering choices, minimizing controls and acknowledging feelings. It is also known in education, that stronger intrinsic motivation leads to enhanced academic performance (Deci, Vallerand, Pelletier, Ryan, 1991; Bulent, 2015). Deci et al. (1994) also states that meaningful exercises also play a role in motivation. Studies have been conducted about motivational factors of gamification where gamification is adding game elements in learning. According to Keller (1987), gamification increases the students' attention through the use of different media, raises confidence by offering satisfaction or rewards gained by learner during the process and makes learning more relevant to students. Gamification can also provide individual feedback for each student, which is also strongly related to autonomy. Keeping in mind the possibilities of mobile phones, we concluded, that mobile based intervention should increase students' intrinsic motivation, by having elements of gamification, increase students' belongingness, offer students choices when completing an assignment, give students' individual feedback and/or include meaningful tasks for students.

This PhD study is part of a large-scale research project "Smart technologies and digital literacy in promoting a change of learning", which is supported by the Estonian Research Council. The first phase of the mentioned study has already been conducted and focused on investigating factors which explain, in general, the access and usage patterns of mobile learning technologies (in this context, smart phones and tablets) and the potential use of such technologies for learning purposes by STEM teachers and students, in particular. The results of phase one form an important base for fulfilling the main goal of the current PhD study, which is to develop evidence-based interventions with mobile devices to be integrated into science and mathematics classrooms in lower secondary school and testing the interventions through a large-scale intervention to provide a conceptual framework for the use of mobile learning technologies in science and mathematics learning.

Based on the goal, four research questions are formulated, put forward as:

1. How can mobile devices be used in science and mathematics classes in order to increase students' inquiry skills?
2. How to use mobile devices in science and mathematics classes in order to increase students' motivation?
3. Does immediate feedback with a mobile device increase students' motivation?
4. Does immediate feedback with a mobile device increase students' inquiry skills?

2. Methods

1. Conducting a literature review to identify the characteristics that are important in developing interventions for identifying the purposes of science and mathematics learning and the potential role of mobile learning technologies (autumn 2017).

2. Choosing, evaluating and adjusting appropriate methods (including instruments to measure learning outcomes) for the role of learning software to be used in the interventions (spring 2018).
3. Designing the interventions in co-creation with teachers, so as to combine best practices and novel ideas (spring 2017/autumn 2018).
4. Piloting the interventions in schools, gathering information from involved students with the help of pre- and post-tests, observations and interviews plus from teachers through post piloting interviews (spring 2017/autumn 2018).
5. Professional development and consultation to engage teachers who are to be involved in the large-scale studies evaluating the interventions (autumn 2018).
6. Carrying out large-scale interventions in schools using experimental and control groups, data collection and analysis, enhancement of interventions (spring 2018).
7. Analysis of the results and development of the conceptual framework for using mobile learning technologies in science and mathematics learning (autumn 2018/spring 2019).

Currently the focus is on improving the intervention according to the information gathered in the pilot study.

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