Teaching based augmented reality and smartphones to promote learning motivation among middle school students

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Abstract: Educators' attitudes toward wireless devices are mixed. Some teachers perceive them as a distraction to the educational process while others report the benefits of wireless devices to the learning process. The aim of this study was to examine the extent to which middle school students' use of smartphones for teaching affects students' motivation. Moreover, it explored students' attitudes toward the implementation of smartphones in education: the types of usage they implement and suggest and whether they think that smartphones should be implemented in schools at all. The findings showed that students were highly motivated compared to the control group; they expressed willingness to conduct such activities in the future and said they would be excited to develop an activity of their own.

Introduction

In the last decade we have witnessed the advent of mobile technologies, among them the "smartphones". These phones have become one of the most common devices for surfing the Internet at any time and any place. There are also additional technologies which are facilitated due to the innovative devices and surfing solutions. The adolescents are consumers of these innovative technologies and use them for different and diverse purposes.

Teaching in the 21st century, an era in which the ICT revolution is in full swing, requires teacher and student preparation to educational settings by using relevant, meaningful and challenging teaching methods, and by leading innovative pedagogy. We live in a reality whereby students own multimedia and personal communication devices, and are constantly acquiring new skills of information sharing and communication (Sharples et al. 2007). Hence, traditional classroom models where exams are held, content and dialogue are dictated by the curriculum and managed by the teacher do not fit in easily. Traditional schooling is very different from the wealth of interactions that students experience outside of school through the use of cellular phone calls, text messaging and virtual communities. These two worlds come into conflict when children bring mobile devices to school. Rather than focusing on the threat of mobile technologies to formal teaching, technological changes can be regarded as a positive challenge to schools, and a means of bringing the teaching into the mobile technology age. Proper harnessing of the available technological means may facilitate flexible learning, that is, learning without

the boundaries of time and place, characteristics that are increasingly in demand in the 21st century.

The aim of this study was to examine the extent to which the use of smartphones for teaching affects students' motivation as well as their attitudes toward the implementation of smartphones in education; the types of usage they suggest and whether they think that smartphones should be implemented in schools at all.

21st century skills in the school context

Teaching in the present era calls for reference to technological transformations as well as attention to the definition of school, teachers, learners and curriculum. Teaching in the current era requires educators to consider technological changes and to take into consideration the gap between classroom practices and practices beyond it. For the increased incorporation of technologies, Daggett (2005) argues that a shift in focus is necessary, from teacher-centered instruction to student-centered learning in which teachers take a secondary position as directors, guides and supporters of the learning process. They believe that this is the only way for developing learners' leadership skills, teamwork as well as necessary and relevant competences which will assist them to cope with challenging daily issues. According to Daggett, this will help students to develop leadership skills, teamwork and other competences necessary and relevant to challenging issues in everyday life and the needs of the future workforce. Additional skills required are creativity and ingenuity, communication and collaboration, critical thinking and problem solving (Salpeter, 2003). Training programs that take into consideration technological changes must be committed to address the reform needed in teaching methods and take advantage of the potential of mobile technologies for an innovative pedagogy in education.

Mobile learning can be implemented 24 hours a day 7 days a week. It allows mobility at five levels: mobility in the physical space, technological mobility, mobility in the conceptual space, mobility in the social space and decentralized learning (Sharples et al., 2009). Mobile technological devices are highly common among youngsters. The international PEW survey of digital communication (Madden et al., 2013), conducted in the United States among adolescents aged 12-17, illustrated the high incidence of mobile phone and Internet usage. 37% of the youth have smartphones and 1 out of 4 (23%) has a tablet computer. Among the adolescents, 74% use a mobile device to get connected to the Internet and 1 out of 4 uses the smartphone for surfing the net. About 50% of the youngsters who own a smartphone use it for surfing the Internet. 95% of the adolescents are connected to the Internet online while moving and throughout the entire day.

Morgan (2010) presents the advantages and disadvantages involved in the integration of mobile devices such as smartphones tablets and handhelds in learning. Among the salient advantages she indicates the degree of convenience of using small and easy-to-carry devices with connection to a wireless network at any time and any place. These devices are available as compared to other computer types. Morgan believes that using these devices promotes the green culture of schools (reduces the number of printed pages);

teachers find it easier to accompany the learning process; teaching methods are diversified; and level of motivation of both students and teachers is enhanced. Along with the advantages, Morgan references various concerns regarding the integration of mobile devices: the availability of these devices will disrupt students' attention, will lead them to make inappropriate uses during the lesson, and might induce students' addiction to electronic stimuli. She is aware of the fact that many schools prohibit the use of these devices. However, the integration of these devices pending effective control measures could empower and promote the learning.

Mobile technologies, teaching and motivation for learning

Smart mobile devices allow the collection, organization, storage and presentation of information. They are equipped with advanced multimedia players, provide access to recently updated information, store contacts and enable real time communication, using a wide range of Internet environments. They also facilitate the synchronization of information regularly and access to it anywhere, any time.
When considering the use of mobile technologies in education, one promising aspect is student motivation. Learning by means of these technologies is often perceived by students as informal, enjoyable and motivational, even if it does not involve interactive games. Fundamentally informal learning emphasizes learners' goals and interests rather than learning goals, and therefore has the effect of strengthening learners' internal motivation (Sharples, 2007). Students engaging in mobile learning report that this gives them a sense of heightened control, ownership and fun, allows enhanced communication and enables learning in context (Jones et al., 2007; Sharples, 2007).
Mobile technologies offer many options that can be useful in teaching. Laurillard (2007) suggests designing learning activities that take advantage of the uniqueness of the technology. These technologies enable discovery and study of physical environments, maintaining synchronous and a-synchronous dialogue with colleagues. Mobile technologies also offer many options of information capture, access and manipulation. Enhanced feedback is also possible, as mobile platform allows for the tracking of processes.

The theory of self-determination conceived by Deci & Ryan (2000) assumes that three congenital basic needs underpin people's behavior. The first is the need for autonomy – people need to feel that their behavior is not dictated to them but rather expresses their needs and authentic inclinations. The second is the need for competence – people need to feel that they have the competences and skills for accomplishing difficult goals. The third is the need for connection and relatedness – people need to love other people and be loved by them and thus be part of a larger community. According to this theory, satisfying these needs will entail people's deep and high quality involvement in the activities in which they engage. Conversely, oppressing or preventing the satisfaction of these needs, will undermine the quality of motivation and will sometimes even reduce its intensity. This led to the development of an augmented reality teaching unit in the field of sciences.

Augmented Reality Technology and Education

Many cellular tools and applications that are being developed are not specifically intended for educational purposes, but can nevertheless be used in the process of teaching and learning. One example is augmented reality digital information, known as "AR". Through AR, learners are able to gain immediate access to a wide range of location-based information, compiled and provided by a variety of sources. Students can be engaged in and motivated to explore class materials from different angles (Kerawalla, Luckin, Selijefot, & Woolard, 2006) and gain real-world first-hand experience in subjects that were not feasible otherwise (Shelton & Hedley, 2002). These benefits of augmented reality technology make the technology relevant for learning. Johnson et al. (2011) note several pedagogical reasons for implementing AR: it is a convenient tool for integrating visual content learning; it responds and acts according to the student's actions, facilitating interactive learning and enhancing the learning and self-evaluation process. In addition, the technology allows students to construct new knowledge based on interaction with virtual objects that are not always within reach of the student. Using augmented reality enables the teaching of complex content in a user-friendly and more tangible manner. These technologies bridge the gap between physical and digital content, since they allow access to digital content based on printed materials (Johnson & Adams 2011). These features of mobile technology require educators' attention in order to harness these resources to teaching and to formulate and adopt an updated pedagogy.

Pedagogical Uses of Advanced Mobile Devices

Wireless devices serve as a "compass" for finding new information (Vandi & Djebbari, 2011) and enable access to location-based information on the basis of interest and personal need (Hicks & Sinkinson, 2011). Among the advantages of mobile learning are the ability to design cooperative, contextual, constructivist and authentic learning. This type of learning integrates mobile learning and flexible teaching strategies.

Mobile devices can be used for investigating new content by turning passive data sources that contain huge amounts of information into interactive objects (Vandi & Djebbari, 2011). This makes learning more relevant, allowing learners to access information at the right time and place. Providing the opportunity to interact with the learning materials enables a kinesthetic learning approach. The use of space-based technology will expand as educators become aware of the existence of free and accessible technologies, their ease of use and the level of their mobility. Mobile resources can be an ideal way for providing immediate assistance to students through the devices they own and use by themselves, in order to provide background on what is learned and to enable individually-paced learning (Chen, Teng, Lee & Kinskuk, 2011). The aim is for students to efficiently and effectively use mobile devices to enrich the learning experience (Fasimpaur, 2011). In addition, the use of mobile devices is advantageous in reducing memory load, making students satisfied with real-time support and facilitating classroom management processes.

Incorporating mobile technology in teaching can enable educators to bridge the gap between the school environment and the extracurricular environment. Allowing learners to use technologies in which they are versed can empower students and enrich learning, making it more meaningful and relevant. Embracing these technologies and using them correctly is certainly more constructive than the attempts to fight and resist technology in the classroom.

In conclusion, mobile phones and mobile applications offer a wide range of opportunities to educators and learners as well as the community by preparing its members for the wide range of subjects and skills necessary for the 21st century. The ubiquity of mobile devices today along with their empowering potential make mobile technologies a great candidate for integration in learning and useful for the skills needed for the future. While it is clear what educators and pedagogues think of mobile integration in the classroom, students' opinions are still underexplored.

Research aim and research questions

The research aim is to investigate the relation between learning by means of augmented reality technology and smartphones and motivation for learning. The research aim gave rise to two research questions which specify the motivational elements relevant to this study as follows:

1. Is there a difference in the degree of interest in the lesson between a group of students who learnt the topic "mechanical interactions" by means of the augmented reality technology and smartphones and a group of students who learnt the same topic without using these technologies?

2. Is there a difference in the students' sense of self-efficacy regarding tasks given during the lesson between a group of students who learnt the topic "mechanical interactions" by means of the augmented reality technology and smartphones and a group of students who learnt the same topic without using these technologies?

Method

Participants
This study was conducted during 8th grade sciences lessons which constitute part of the curriculum sequence. The study was based on an experiment conducted with two middle school student groups consisting of 59 eighth grade students (two classes), learning a science unit using augmented reality smartphone technology, and their counterpart group which consisted of 57 eighth grade students (two classes) who learned the unit in a traditional manner.

Based on the data published by the Central Bureau of Statistics, the socio-economic level of the locality where the students are living and where the school is located is ranked relatively high, namely 8 out of 10 (10 being the highest rank). The principal requested to maintain the anonymity of the students and of the school. Hence, the name of the locality where the study was conducted was not indicated in the body of the work.

This is the second year that the teacher has been teaching at that school. The 7th to 9th grades of the middle school number on average about 10 classes per age group. At this school the use of mobile phones is prohibited during lessons. For the purpose of the research the teacher received the authorization of the principal to implement smartphones while delivering the teaching unit.

The sciences lessons taught in these classes are characterized by the use of technological aids: one laptop (the teacher's), a projector installed in the classroom and access to the Internet. The use of technology aims to diversity and enrich the learning experience by means of various tools: interactive presentations, simulations, movie clips, educational games as well as searching and sharing information. Within the framework of physics studies as part of the sciences lessons of the 8th graders, the students acquired from the school a work brochure for reading and practicing.

The activities implemented

The teaching unit constitutes an attempt to renovate students' traditional teaching methods by using simple and convenient aids. This will expose students to innovative applications of their smartphones for the purpose of learning. The aims of developing a teaching unit by using augmented reality technology were to facilitate a multimedia-based teaching unit while experiencing the augmented reality technology and its contribution to the teaching of interaction in sciences and technology lessons. Another aim was to enhance the motivational elements for learning: students' interest in the lesson and sense of self-efficacy for accomplishing the tasks given in the lesson by using augmented reality technology and smartphones.

Developing the teaching unit at the pedagogical level is grounded in the interaction chapter included in the students' work brochure: "Electricity, powers and movements" edited by Shosh Banao. Augmentation of the worksheets was done through the technology suggested by Layar (http://www.layar.com/(, i.e. the Layar technology which enables augmenting printed and digital pages through various layers of digitation. Using their own smartphones enabled the students to bypass the fact that they had no computers available at school. The activity included watching animations, videos clips, pictures, listening to podcasts, conducting collaborative activities in Google Docs and sharing them through their smartphones.

Procedure and Instruments

Data presented in this study was collected before and after the activity through a pre- and a post-questionnaire. The 8th grade groups were compared based on an existing

questionnaire (Midgley et al., 2000) of motivational components: level of interest and the perception of self-efficacy. The questionnaires were administered to participants before and after completing the science activity.

The study was conducted by qualitative and quantitative analysis. The analysis method is grounded in inferential statistics and it was performed by means of independent t-test. The comparison between the groups was based on the data obtained from the pre-lesson and the post-lesson questionnaires. The questionnaire reliability was checked by the Cronbach's alpha index for the variable of the students' level of interest in the field of sciences separately from the students' sense of self-efficacy. Additional information was collected based on the questionnaires, correspondence and conversations with the students and the teacher.

The students in both the experiment and control groups learnt a teaching setup which consisted of two consecutive lessons about the topic of "Mechanical interactions". The lesson structure of the control group included: discussion, conceptualization, experience, working with the brochure and summary while using a presentation-accompanied lesson. The teaching setup of the experiment group comprised work with the students' smartphones while using the Internet and the Layar application.

A preliminary examination illustrated that about 80% of the students have a smartphone with access to the Internet. Thus, the work on the unit was planned in pairs. The students were asked ahead of time to download the Layar application to their smartphones. The teaching setup included an explanation about the teaching unit, the way of working and using the augmented reality technology and working in pairs on the teaching units combined with tutoring by the teacher. It also included a lesson summary consisting of: checking comprehension of the studied material, presenting the results of the electronic questionnaire performed on Google docs and their projection on the classroom board, screening of the movie clips produced by the students in the class while working on the teaching unit and the reflection on the lesson.

The level of interest was examined by means of a questionnaire which comprised eight assertions (for example: knowing sciences is highly useful for me; I enjoy learning and using knowledge from the field of sciences) ($\alpha=(0.93$. The students' perception of their self-efficacy in the field of sciences was investigated by means of a 6-item questionnaire (for example: I am sure I can learn what the teacher is going to teach in sciences until the end of the year; I am confident I can find the way for performing the most difficult tasks in sciences if I only try) ($\alpha=(0.81$. The participants were asked to respond on a scale of 1 to 5, with 1= "not at all" and 5 = "to a very great extent".

Findings

Among the students, 78% owned a smartphone whereas 22% did not. Three percent of the students did not have connection to the Internet. The middle school students almost did not experience technical problems during the activities.
The research findings presented in this chapter relate to three statistical analyses. The first statistical analysis was performed in order to check the reliability of the questionnaires

administered within the framework of the research tools. The second statistical analysis was carried out in order to identify the extent of similarity or dissimilarity between the experiment group and the control group before the lesson. A third statistical analysis was done in order to examine the differences between the experiment and control group following the lesson.

In order to examine the difference between the experiment group and the control group before the experiment, a t-test was implemented.

Table 1 demonstrates presentation of t-test results for Motivation and Self-Efficacy of the experiment group and the control group in the pre-test.

Table 1
Descriptive Statistics and t-test Results for Motivation and Self-Efficacy in the pre-test.

Outcome	Experiment Group		Control Group		t	n
	M	SD	M	SD		
Motivation	3.84	0.99	3.47	0.80	*2.13	57
Self-Efficacy	4.30	0.54	4.13	0.69	*1.49	57

* p < .05

The findings indicate a significant difference between the mean values of both groups regarding students' level of interest (t(113)=2.13, P<.05). Regarding the students' sense of self-efficacy in the field of sciences, the findings do not show a significant difference between the mean values of both groups (t(113)=1.49, P<.05). Following the experience, a questionnaire was administered for the purpose of checking the students' level of interest and their sense of self-efficacy. The questionnaire was given to both the experiment and the control groups.

Table 2 demonstrates presentation of t-test results for Motivation and Self-Efficacy.

Table 2
Descriptive Statistics and t-test Results for Motivation and Self-Efficacy

Outcome	Pretest		Posttest		t	n
	M	SD	M	SD		
Motivation	3.84	0.99	4.38	0.66	*4.98	57
Self-Efficacy	4.30	0.54	4.39	0.69	*4.65	57

* p < .05

Results of the t-test show that 8th graders who experienced AR technology were highly motivated compared to the control group: an average level of interest in the experiment group of (M = 4.4) compared to the control group (M = 3.7) and was found significant (t (114) = 4.98, P < 0.05). As for the perception of self-efficacy, the average rate of the experiment group that experienced AR was higher (M = 4.39) than the average of the control group (M = 3.78) and was found to be significant (t (114) = 4.65, P <.05). Due to the fact that in the pre-tests comparison, a significant difference was found regarding

students' level of interest, between the experiment group and the control group, an additional test was conducted. The comparisson regarding students' level of interest between the experiment group and the control group demonstrated a significant improvement in the level of interest of the experiment group as compared to the pre-test $(t\,(113) = 6.17, P <.05)$.

Following the activity, school students think that smartphones could assist them in their learning. For example, searching for information, finding the meaning and translation of words, instead of writing in a notebook, conducting tests, learning new things through different applications, photographing the board instead of taking notes. One student stated that using his smartphone helps him to concentrate and enables him to learn more.

Conclusion

Using personal devices (BYOD) involves bypassing wear and tear problems, the need for institutions to seek for availability up to date and maintenance of devices. Despite the benefits of having students bring their own devices, it is necessary to deal with the variability and the wide variety of devices which students possess and find means to deal with technical difficulties.

Middle school students were very excited about the prospect of incorporating cell phones and AR into their learning. Incorporating smartphones and AR can increase the elements of interest rate and provide students with a learning space in which they can act and research different topics, having the teacher spark their imagination and guide them along the process. Designing the learning environment in a way that harnesses the potential of available technologies and engages the learners can promote a number of factors such as the level of motivation: pleasure, curiosity, access to information, interactivity, diversity and address learning differences. From the teacher's perspective, preparing the units was an innovative and intriguing experience which propelled her on a professional level as professional teachers in the 21st century. Implementing the unit and documenting students' reactions increased the teacher's motivation to design innovative educational activities in order to get closer to the world of the students and use the available computer whenever needed.

The main research limitations are the short duration of the teaching unit, two lessons. It is highly likely that the innovation of the teaching method had a considerable impact on students' motivation and sense of self-efficacy for learning. Another limitation of the research was that no comparison could be performed between the pre-test and the post-test for each student. This was due to the fact that the principal did not allow putting the students' names in the questionnaires in order to maintain their anonymity. Moreover, it is quite possible that the fact that the students worked in groups affected the research findings.

This study sheds some light on the questions that each new technology raises during its first implementation stages. One of the objectives of education is to encompass and integrate as much content, pedagogy and technology as possible, so when educators

create learning materials and innovative teaching methods they actually incorporate the language, the environment and the reality of their students.

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