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THE IMPACT OF AN OUTDOOR MOBILE-SUPPORTED LEARNING ACTIVITY ON STUDENTS' MOTIVATION, PERCEIVED PERFORMANCE, AND SATISFACTION

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Introduction

Science, technology, engineering, and mathematics (STEM) education is facing unprecedented challenges nowadays due to the increasing demand of careers in science and technology from one side and the decreasing interest of students to follow these careers from the other. According to the European Commission – Directorate General for Research and Innovation, one million net additional researchers are needed in Europe by 2020 to meet the research and development intensity target of 3% of GDP (Scientix, 2011).

Appropriate teaching and learning approaches, supported by innovative educational technologies, may be employed in order to enhance students' motivation and interest towards STEM. These approaches need also to be in line with the twenty-first-century learning skills (essential for success in a highly digital and globalized world), such as critical thinking, problem solving, communication, and collaboration, as defined by the Partnership for 21st Century Skills (2007).

The current study implements a mobile-assisted outdoor educational activity in a botanic garden during an environmental education project. It compares learning motivation, perceived learning performance, and satisfaction in terms of learning approach between students who participated in learning activities supported by either traditional paper-based material or mobile devices in the process of scientific inquiry in outdoor learning. This study fills a gap in the literature, because mobile learning in Greece is in its infancy and there are not many studies evaluating its effectiveness or investigating students' attitudes towards it. Also the study provides additional evidence on the impact of mobile learning on student learning motivation, perceived performance, and satisfaction in terms of learning approach in the context of inquiry-based outdoor education. Paper outline is as follows: it first introduces the concepts of outdoor learning, science inquiry, and mobile-assisted outdoor learning. Then it presents the research design, followed by the results, discussion, and conclusion.

Literature Review – Theoretical Background

Outdoor Learning in Botanic Gardens

In the light of motivating students towards STEM, one innovative educational approach that provides meaningful contextual experiences in authentic situations is outdoor learning. It has been found to be an effective way of learning (Palmberg & Kuru, 1998), it complements and expands classroom instruction (Knapp, 1996), and it is associated with better student engagement in learning and higher levels of academic achievement (Dillon, 2007). Outdoor learning can take place outside the physical boundaries of the traditional classroom in contexts such as museums, historical sites, science parks, scientific labs, and botanic gardens, as informal or part of formal learning curriculum. According to the International Agenda for Botanic Gardens in Conservation (BGCI, 2012), the definition of a botanic garden is: "Botanic gardens are institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education" (p. 9). They are usually situated in urban areas and, since they contain a large collection of plants, they can offer many learning opportunities and hands-on experiences in natural sciences (i.e., environmental education, biology) for students.

Inquiry-Based Science Education in Botanic Gardens

One educational approach that is very well suited to outdoor learning is inquiry-based learning. The Inquiry-Based Approach to Science Education (IBSE) uses the scientific inquiry as the main educational vehicle and allows students to become researchers rather than simple recipients of a scientific topic. It is based on the pedagogical theory of constructivism, where the student is in the focus of educational practice, while the teacher acts as a facilitator for students, providing them with guidance to explore the subject of study. The cycle of inquiry can be identified as: asking, investigating, creating, discussing, and reflecting (Bruce & Bishop, 2002). Hakkarainen (2003) proposed the following stages for the IBSE teaching and learning procedure: formulating questions, gathering and analyzing data, and constructing evidence-based explanations and arguments. The active and collaborative engagement of students in the scientific inquiry enables sound knowledge acquisition and deeper understanding of the subject matter.

The European project INQUIRE: Sustainability and Biodiversity Training, about IBSE in relation to climate change and biodiversity, demonstrated how IBSE can inspire students in science and help address biodiversity and climate change (Tavares et al., 2014).

Mobile-Assisted Inquiry-Based Outdoor Learning

Mobile learning, defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Crompton, 2013, p. 4), can be conceptualized as informal, personalized, and situated (Kukulska-Hulme & Traxler, 2005), allowing "learning tasks built around data capture, location-awareness and collaborative working" (Traxler, 2009, p. 18). Context awareness is one of the main issues in mobile learning which distinguishes it from the general notion of e-learning. Context has been defined as consisting of the learner state, the educational activity state, the infrastructure state, and the environment state (Economides, 2008).

A context-aware ubiquitous learning activity is capable of enhancing students' motivation and learning effectiveness (Shih, Chu, Hwang, & Kinshuk, 2011). Learners' participation in a mobile learning group in a museum learning activity was greater than that of the traditional approach (Hou, Wu, Lin, Sung, Lin, & Chang, 2014). Mobile technologies can effectively support inquiry-based learning as well (Jones, Scanlon, & Clough, 2013). Hwang, Wu, Zhuang, and Huang (2011) found that the inquiry-based mobile learning approach had better learning achievement and less cognitive load than the traditional approach.

The current study considers only one of the dimensions of the learner's state, which is location (Economides, 2009). There are numerous technologies for locating the learner (radiofrequency identification (RFID) tags, global positioning system (GPS), sensor networks, quick response (QR) codes). This study uses QR codes, an inexpensive and easily developed and administered way of integrating digital content with real-life objects.

Location Awareness and QR Codes

QR code is a form of two-dimensional barcode, readable by a QR-scanning application installed on a camera-equipped mobile device. Associated with a QR code is usually a uniform resource locator (URL) that can be accessed through a mobile web browser. The investigation of the applications of QR codes in educational contexts is an ongoing field of study. QR codes are usually implemented in the context of mobile learning. Possible uses are links to electronic resources such as instructional videos or useful websites for further information (Walsh, 2010), foreign-language listening exercises, and self-evaluation exercises (Law & So, 2010), or in class quiz applications as lecture surveying tools (Schon, Kopf, & Effelsberg, 2012).

QR codes may provide great support to outdoor learning as well, such as trail activities and treasure hunts. Lee, Lee, and Kwon (2011) incorporated QR codes and smartphones into field trips for biology classes. Chin and Chen (2013) developed a mobile learning support system for ubiquitous learning based on QR codes and GPS technology that facilitates student learning in outdoor settings. Rikala and Kankaanrant (2012) introduced different educational QR code implementations and found that they can facilitate learning in different contexts as well as motivate and engage learners. The current study implements a mobile-assisted outdoor educational practice in botanic gardens in Greece.

Research Method

A quasi-experimental pre–post-test research design was used to investigate the impact of mobile devices on K-12 student learning motivation, perceived learning performance, and satisfaction during an outdoor learning activity in botanic gardens. Motivation is one of the main driving forces in learning and, by analyzing student motivational patterns, educational practices can be improved in order to obtain better learning outcomes.

The main part of the study was conducted in a botanic garden, during an environmental course about plant biodiversity in an upper secondary school in an urban area of Greece. During this activity students had the opportunity to explore a wide variety of plants and identify their special characteristics, find out how they can be used in pharmacology, medicine, aromatics, and nutrition, and discover how plants are essential in a balanced ecosystem and why biodiversity is important.

Participants

The participants were 39 students (average age 16.2 years old, SD = 1.2), 16 boys (41%) and 23 girls (59%). Students were randomly assigned into two groups. One group (18 students) was assigned to be the experimental group and the other (21) was the control group. Students in the experimental group were asked to express their confidence about mobile usage using a valid and reliable questionnaire adopted from Kenny, Neste-Kenny, Burton, Park, and Qayyum (2012). The questionnaire assesses mobile self-efficacy based on measuring judgments of capability that varies across specific realms of activity (Bandura, 2006). Students in the experimental group were confident enough to use their mobile devices during the learning activity since their median mobile self-efficacy score was 78 on a scale of 100.

In order to access the learning and assessment material, students in the experimental group were asked to use their own wi-fi-enabled and camera-equipped smartphones, while students in the control group used paper and pencil instead. While paper-based learning material is a traditional and convenient way to study, mobile devices, due to their connectivity and portability, are very well suited to outdoor learning (Sharples, Taylor, & Vavoula, 2005). The affordances of this innovative medium overcome their constraints and make it an appropriate way to deliver assessments (Nikou & Economides, 2013).

Procedure

The experimental procedure consisted of the following three stages:

- Stage 1: Three introductory in-class lessons about plant morphology, taxonomy, and biodiversity preceded the main learning activity in the botanic garden. During this first stage, a series of questions regarding biodiversity and plant species were formulated by the students and teacher according to the inquiry-based educational model. These questions were uploaded in a questions database and made available to the students during the second stage.
- Stage 2: This stage involves the outdoor learning activity, i.e., the students' visit to a botanic garden, as Figure 4.1 shows.

FIGURE 4.1 (a), (b) Mobile-supported science inquiry in botanic gardens.

The time duration was 3 hours. Students were guided to the different parts of the botanic garden by appropriately delivered mobile-based or paper-based instructions for the experimental and control group accordingly. When a student approached a plant (learning target) he/she had to answer a series of questions (from the questions database created in the previous stage) concerning plant morphology, taxonomy, and usage and its contributing role in biodiversity as well. Examples of such questions are "How would you identify the conifer species?", "How many different leaves can you find among conifers?", "What characteristics make a specific type of flower unique?" or even "Why are olive trees of great economic value for Greece?" Access to the questions database was provided through smartphones with the facilitation of QR codes for the experimental group and traditional paper-based material for the students in the control group. QR codes is an inexpensive and easily implemented method of linking supplementary digital resources to real-world objects. Students in the experimental group, using their mobile phones, had to scan the QR code attached to the plant under investigation (learning object).

Without needing to type the link into their tiny mobile phone keyboards, the corresponding question automatically retrieved and displayed on students' smartphone screen along with any supplementary information (when appropriate). Upon question retrieval, students had to carefully observe the plant, read the information provided either online or on the informative sign located next to the observed plant, answer the corresponding question, and upload it to the answers database. Figure 4.2 depicts the mobile learning approach implemented during this inquiry approach for the experimental group.

The ultimate learning goals were for students not only to observe, describe, and compare different plant species and their characteristics, but also to familiarize themselves with the science inquiry method and to develop positive attitudes and values towards ecosystems and biodiversity.

- Stage 3: Back to class – this stage corresponds to the discussion and reflection stage of the inquiry-based model. During this last stage, students presented their answers along with the corresponding questions to the class, where a discussion about the plants' special characteristics and their role in biodiversity followed.

Data Analysis

Students in both the control and experimental group were required to self-report their level of learning motivation before the inquiry stage as well as after the learning activity along with their perceived performance and satisfaction with the learning activity. Figure 4.3 depicts this research design.

Analysis of variance tests performed on the data collected before the learning activity (pre-test) showed no significant difference in learning motivation, at the

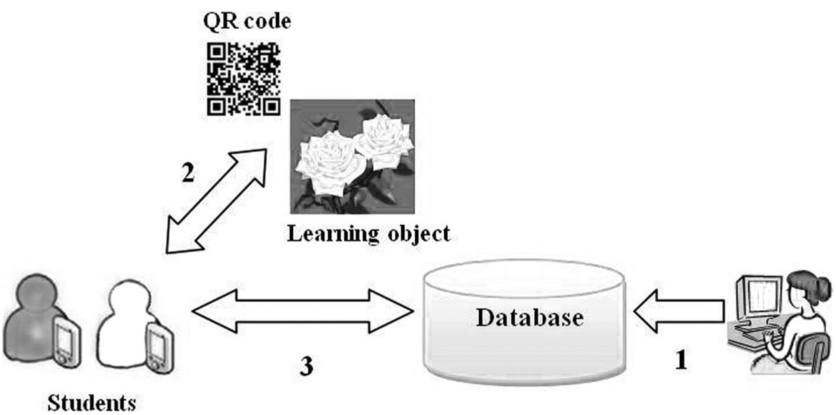

FIGURE 4.2 Mobile learning approach for the inquiry stage. 1, Questions are uploaded to the database. 2, Students use QR codes. 3, Questions are fetched to students' mobiles and their answers are uploaded to the database.

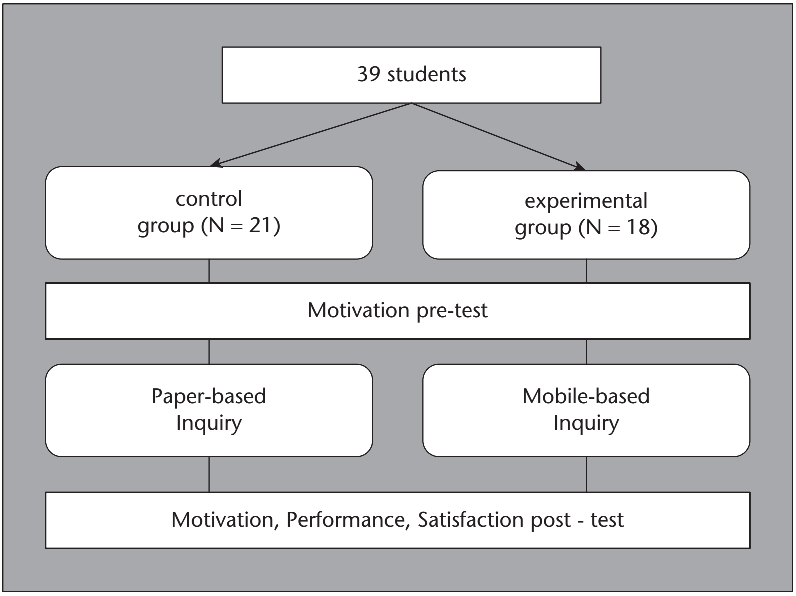

FIGURE 4.3 Research design.

$p < 0.05$ level, for both the control and experimental group ($F(1,37) = 0.079$, $p = 0.865$). After the outdoor learning activity, all students completed the questionnaire (post-test) for learning motivation, perceived learning performance, and satisfaction in terms of learning approach. The questionnaire consisted of three questions regarding students' perceptions about their participation into the learning activity. We used the 5-point Likert-type scale, with 1 = strongly disagree to 5 = strongly agree, in order to measure the items. Table 4.1 shows the questions

TABLE 4.1 Comparison of post-testing evaluation for motivation, performance, and satisfaction

Questions	*Control group*		*Experimental group*		*t-value*	*p-value*
	Mean	*SD*	*Mean*	*SD*		
The outdoor learning activity promotes my learning motivation	3.78	0.61	4.34	0.73	3.90	0.021*
The outdoor learning activity improves my learning performance	3.52	0.59	4.21	0.67	3.29	0.029*
I like to participate in the learning activity	4.11	0.96	4.79	0.87	2.36	0.032*

*$p < 0.05$.

along with the results for both the control and experimental group for the post-testing evaluation.

All the mean values are high for both the control and experimental groups, with higher means for the experimental group. When the experimental group was compared with the control group, after the learning activity was implemented, significant differences were found with learning motivation, i.e., "The outdoor learning activity promotes my learning motivation" ($M_{exp} = 4.34$, $M_c = 3.78$, $t = 3.90$, $p < 0.05$). Significant differences were found for perceived learning performance, "The outdoor learning activity improves my learning performance" ($M_{exp} = 4.21$, $M_c = 3.52$, $t = 3.29$, $p < 0.05$) and learning satisfaction also, "I like to participate in the learning activity" ($M_{exp} = 4.79$, $M_c = 4.11$, $t = 2.36$, $p < 0.05$). The experimental results show that learning motivation is improved for the mobile-supported science inquiry. Also perceived learning performance and satisfaction are higher for the mobile-assisted group.

Discussion

The current study incorporates mobile devices into the learning procedure during outdoor environmental inquiry. Specifically, it proposes a mobile-assisted model to obtain supporting evidence while answering and explaining inquiries in the context of a scientific inquiry. Using QR codes and mobile technologies is an easily reproducible learning activity that creates a ubiquitous learning environment combining real-world and digital-world resources.

The responses to pre- and post-test questionnaires of the control and experimental group indicate that learning motivation, perceived performance, and satisfaction are higher for the mobile-assisted outdoor learning activity. The study provides further evidence that mobile learning can facilitate science inquiries outdoors for K-12 students in Greece. This study is one of the first of its kind to be implemented in the Greek educational setting, and its findings are in line with previous research (Hwang et al., 2011; Rikala & Kankaanrant, 2012; Shih et al., 2011) in different cultural contexts. A few occasional negative experiences reported by students (mostly regarding wi-fi connectivity issues) were not strong enough to diminish the perceived positive attitudes towards the use of mobile devices and their impact on student motivation.

Deci and Ryan (1985) suggested that motivation can be enhanced when the learning activity is tailored to the unique individual needs of the learner. Mobile devices do have the potential to offer personalized learning experiences at the appropriate timeframe and therefore to increase learning motivation. An increase in learner motivation (intrinsic or extrinsic) leads to better learning performance. Analyzing learners' motivational patterns during learning activities, suitable learning strategies may be designed and implemented by educators and educational policy makers. Mobile devices can play an important role in this educational reform since they can link real-world objects with digital learning content, enhancing the learning experience. One of our future research directions is to examine possible learning gains that mobile devices can offer not only through linking virtual with real-world learning objects but through the collaboration and adaptation mechanisms they can support as well.

Proposing a mobile-assisted learning activity outside the classroom boundaries, this study indicates the need, especially for educational settings where the value of mobile learning is still underestimated, to consider more carefully the use of mobile devices for learning purposes. Beyond the arguments against their use in education (student destruction, privacy issues, costs, etc.), mobile devices, when used appropriately, can provide a promising tool for scientific inquiries in outdoor education and science teaching and learning.

References

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents*. Greenwich, CT: Information Age Publishing.

BGCI. (2012). *International agenda for botanic gardens in conservation* (2nd edn.). Richmond, UK: Botanic Gardens Conservation International.

Bruce, B.C., & Bishop, A.P. (2002). Using the web to support inquiry-based literacy development. *Journal of Adolescent and Adult Literacy*, *45*, 706–714.

Chin, K.Y., & Chen, Y.L. (2013). A mobile learning support system for ubiquitous learning environments. *Procedia – Social and Behavioral Sciences*, *73*, 14–21.

Crompton, H. (2013). A historical overview of mobile learning: Toward learner-centered education. In Z.L. Berge, & L.Y. Muilenburg (Eds.), *Handbook of mobile learning* (pp. 3–14). Florence, KY: Routledge.

Deci, E., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

Dillon, J. (2007). Researching science learning outside the classroom. *Journal of the Korean Association for Research in Science Education*, *27*(6), 519–528.

Economides, A.A. (2008). Context-aware mobile learning. The Open Knowledge Society. A computer science and information systems manifesto. *SPRINGER Communications in Computer and Information Science,* 19, 213–220.

Economides, A.A. (2009). Adaptive context-aware pervasive and ubiquitous learning. *International Journal of Technology Enhanced Learning*, *1*(3), 169–192.

Hakkarainen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching*, *40*(10), 1072–1088.

Hou, H.-T., Wu, S.-Y., Lin, P.-C., Sung, Y.-T., Lin, J.-W., & Chang, K.-E. (2014). A blended mobile learning environment for museum learning. *Educational Technology & Society*, *17*(2), 207–218.

Hwang, G.J., Wu, P.H., Zhuang, Y.Y., & Huang, Y.M. (2011). Effects of the inquiry-based mobile learning model on the cognitive load and learning achievement of students, *Interactive Learning Environments*, 1–17.

Jones, A.C., Scanlon, E., & Clough, G. (2013). Mobile learning: Two case studies of supporting inquiry learning in informal and semiformal settings. *Computers & Education*, *61*(1), 21–32.

Kenny, R.F., Neste-Kenny, J.M.V., Burton, P.A., Park, C.L., & Qayyum. A. (2012). Using self-efficacy to assess the readiness of nursing educators and students for mobile learning, *The International Review of Research in Open and Distance Learning*, *13*(3), 277–296.

Knapp, C.E. (1996). *Just beyond the classroom: Community adventures for interdisciplinary learning*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools, Charleston, West Virginia.

Kukulska-Hulme, A., & Traxler, J. (2005). *Mobile learning: A handbook for educators and trainers*. London: Routledge.

Law, C.Y., & So, S. (2010). QR codes in education. *Journal of Educational Technology Development and Exchange*, *3*(1), 85–100.

Lee, J.-K., Lee, I.-S., & Kwon, Y.-J. (2011). Scan & learn! Use of quick response codes & smartphones in a biology field study. *The American Biology Teacher*, *73*(8), 485–492.

Nikou, S.A., & Economides, A.A. (2013). Mobile assessment: State of the art. In Z.L. Berge, & L.Y. Muilenburg (Eds.), *Handbook of mobile learning* (pp. 346–355). Florence, KY: Routledge.

Palmberg, I., & Kuru, J. (1998). Outdoor activities as a source of environmental responsibility. In J.A. Palmer (Ed.), *Environmental education in the 21st century. Theory, practice, progress and promise* (pp. 253–257). London: Routledge.

Partnership for 21st Century Skills. (2007). *Framework for 21st century learning*. Available online at: http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf (accessed August 11, 2015).

Rikala, J., & Kankaanrant, M. (2012). The use of quick response codes in the classroom. In M. Specht, J. Multisilta, & M. Sharples (Eds.), *11th World Conference on Mobile and Contextual Learning* (pp. 148–155). Helsinki, Finland, 15–18 October 2012. Available online at: http://ceur-ws.org/Vol-955/papers/paper_40.pdf (accessed August 11, 2015).

Schon, D., Kopf, S., & Effelsberg, W. (2012). A lightweight mobile quiz application with support for multimedia content. *International Conference on e-Learning and e-Tech nologies in Education (ICEEE),* 134–139.

Scientix – The community for science education in Europe. (2011). European Commission, Research and Innovation DG: Brussels. Available online at: http://www.scientix.eu/ (accessed December 22, 2014).

Sharples, M., Taylor, J., & Vavoula, G. (2005). Towards a theory of mobile learning. In H. van der Merwe & T. Brown (Eds.), *Mobile technology: The future of learning in your hands*. mLearn 2005 book of abstracts, *4th World Conference on mLearning,* 25–28 October, 2005 (p. 58). Cape Town: mLearn..

Shih, J.-L., Chu, H.-C., Hwang, G.-J., & Kinshuk (2011). An investigation of attitudes of students and teachers about participating in a context-aware ubiquitous learning activity. *British Journal of Educational Technology*, *42*, 373–394.

Tavares, A.C., Silva, S., Santos, J., Paiva, I., Oliveira, J., & Bettencourt, T. (2014). Inquire at Coimbra Botanic Garden: Products and process of an IBSE educative project. *Procedia – Social and Behavioral Sciences*, *116*, 4353–4356.

Traxler, J. (2009). Current state of mobile learning. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training*. Edmonton, AB: Athabasca University Press.

Walsh A. (2010). QR codes – using mobile phones to deliver library instruction and help at the point of need. *Journal of Information Literacy*, *4*(1).