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Framing a Model for Mobile Learning Using Augmented Reality

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Abstract: *This paper considers the possibility of creating a framework for mobile learning with elements of augmented reality, intending to better adapt teaching content to students who are in the same or different locations. The framework, in which the use of mobile devices in learning is observed, depends on the purpose for which the mobile device is used (for research purposes, simulation, etc.), on technical capabilities, and the level of user capabilities. The goal is to achieve a quick and efficient understanding of the learning content, as well as good cooperation from the participants. The sustainable link between AR and HE goals must be established in accordance with the cognitive approach, according to the axioms of the theories related to learning, with the aim of unifying the association of this technology with the teaching–learning process.*

1. INTRODUCTION

With the rapid development of mobile technology, augmented reality (AR) is one of the innovative technologies for improving the interaction between real and virtual spaces by superimposing virtual objects or information in a physical environment. Smartphones and tablets with AR technology are being increasingly used as pedagogical tools in education, including science (Lin & Tsai, 2021). Augmented reality can be applied to different aspects of education. In the last few years, there has been an increase in the number of examples of the application of augmented reality in education, with an emphasis on higher education, where better student engagement, better perception, and more positive attitudes have been noted as the effects of the application of augmented reality (Chen et al., 2016). AR technology enables the enrichment of the learning experience, makes learning easier, increases motivation, and improves focus in students (Sırakaya & Sırakaya, 2020).

Mobile devices, by default, offer certain unique advantages which can be utilized in education, such as mobility, social interactivity, connectedness for data sharing within devices, individuality, and the capability to gather real and simulated data from a location and the environment (Klopfer & Squire, 2012). Aside from easier access to learning materials, they also have the potential to ensure individual learning, which used to come only in the form of mentor work between a lecturer and a student (Peters, 2007).

2. MOBILE LEARNING

Correct dimensioning of mobile device usage in the learning process creates a new dimension that can affect the efficiency of learning to gather active experience (Kohen–Vacs et al., 2013). Mobile device usability is viewed through the prism of gathering, adopting, storing, and managing information. In the everyday search for information, there is already a trend of the

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prevalence of mobile devices. Such a type of informal learning provides a basis for the adjustment of formal learning materials to mobile devices for the purpose of better integration.

The usability of a device is viewed through the physical comfort and satisfaction of a student challenged by cognitive stimulation, the acceptance of information, and the ability to move from a physical to a virtual location. The usability of devices ties together the needs and activities of students and the software and hardware components of a mobile device. The high mobility, intuitiveness, and simplicity of a device can decrease cognitive overload, i.e. make task fulfillment easier.

The role of mobile devices in learning, depending on the environment and the topic being learned, should be motivating and relevant when adopting information, especially when location characteristics are used to choose and present the content. The mobile device system should be able to fulfill the following roles:

- Positioning via devices such as GPS, NFC, RFID, QR code, or 2D bar code.
- The creation of "learning paths" through instructions after precise positioning, defining the contents, and following existing activities. These paths can be defined in advance or randomly generated. The more independent students are, the more imminent individual learning paths become (Meek et al., 2012).
- The most important part of the system is the choice and presentation of the learning content depending on the location. Namely, the materials are delivered to a student based on the previously defined positioning, assessment of the connection between the student's location and the materials, as well as based on the individual characteristics of the student. In addition, good interoperability and interactivity between a student and a teacher play a major role in the acceptance of the new learning method, as well as in its efficiency (Nandwani et al., 2012).

The main characteristics of mobile applications are defined, to a large extent, by functional and nonfunctional user requirements. Functional requirements encompass all application settings, which can differ greatly, as applications are very specific. On the other hand, nonfunctional requirements encompass the answers to individual users' requirements, as well as some general requirements that refer to mobile device characteristics, such as the usage of wireless technology, security, privacy, and interoperability.

Through the dynamic experience of mobile applications in learning, and during the process of problem-solving, students coordinate their activities better in the virtual world than in the physical one. As with traditional education, the types of participation include the engagement and motivation of students, especially if some sort of a game is being played, which results in the better processing and memorization of information. The educational materials presented in the form of a game, such as learning foreign languages using augmented reality mobile applications, demonstrate great potential for inspiring teamwork, social interactions, and better results of learning (Liu et al., 2016).

The goal of device usability should be an increase in students' focus on the task at hand, and not the specific tools used to fulfill the said task. Digital information that can be presented on mobile devices can easily integrate into existing materials using various codes, images, or other markers. This opens the door to an increased potential for combining learning resources through mobile technology and augmented reality, all with the goal of improving the understanding of study materials. In the example of using QR codes in mobile learning, students had an evident positive reaction to the augmentation of study materials (Chen et al., 2011).

Criteria used to define the aspect of mobile device usability are the following:

- Device mobility, in terms of moving to another environment without a change in data reception and processing performance;
- Information availability, i.e., access to information from any location at any time. This enables the *just-in-time* learning principle, where information follows the user, i.e., the user can store it and reuse it under identical conditions as when first receiving it, but at a later time when this information is necessary;
- Mental comfort, which encompasses understandability, ease of learning, ease of remembering, and intuitiveness, thus affecting the cognitive load and the rate at which students will fulfill a task. Metaphors, incomplete information and mnemotechnics, complicated displays, or illogicality of activities can impede cognitive performance;
- Student satisfaction in terms of interface esthetics, the physical appearance of the device, and device functionality when learning. This criterion is difficult to predict and define in advance, as satisfaction and enjoyment are defined by the personal and cultural style of each individual. Latest-generation mobile devices use their modern technical characteristics to achieve higher user satisfaction.

When using mobile devices in learning activities, there must be an array of conditions satisfied, which stimulate students to cooperate and interact (Yang et al., 2015):

- Location-related conditions in which students can use mobile devices,
- Access to information whenever and wherever necessary (just in time learning),
- The least possible cognitive overload with materials and activities that can be simplified using mobile device functionalities when fulfilling a task,
- Esthetic and functional approach that can be personalized per the requirements and preferences of the user.

3. THE PROCESS OF MOBILE LEARNING

The process of mobile learning is an intersection between three aspects: mobile devices, learning, and interaction, as shown in Figure 1.

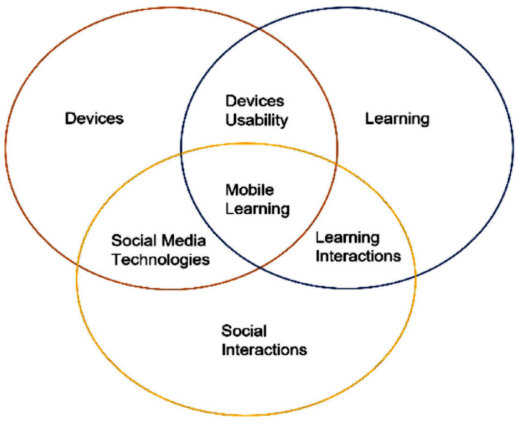

Figure 1. Mobile learning through the prism of mobile devices, learning, and social interactions

Source: Koole, 2009.

The goal of mobile learning is to give a student the competencies for better assessment and choice of information, redefining achieved goals, and questioning the understanding of what

they have already learned. Efficient mobile learning provides an improved cognitive environment where physically distant participants can communicate with each other, instructors, learning materials, and physical and virtual surroundings.

The criteria for assessing the mobile learning process are the following:

- Mediation, which implies that the very nature of interactions between participants replaces the participants in their interpersonal communication, as well as in the interaction with their surroundings, tools, and information;
- Access to information and its selection, which implies that with the increase in the amount of information, students need to increase the amount of effort to recognize the appropriateness and veracity of said information;
- Knowledge navigation, which implies that, based on the learned materials, students acquire the skills necessary to place information in the context of situation and necessity.

In the mobile learning system, the following should be kept in mind:

- The method of mobile device usage that will improve the interactions between students, the community, and the system,
- The students' method of accessing other systems and devices using their mobile devices to confirm or assess the relevance of information and the process flow, all with the goal of fulfilling tasks,
- Students' independence in navigation through information filtering,
- The method of switching the roles of students and teachers with the necessary equipment.

The advantages achieved through the mobile learning process, in addition to offering students interactivity through spoken communication and multimedia access to the Internet, include:

- Using the wireless network, students can reach physical and virtual destinations on their mobile devices,
- The ability to access different materials anywhere and anytime ensures a better understanding and adoption of information,
- Learning in specific contexts can offer the authenticity of the social and cultural environment, which provides a better insight into the application of the acquired knowledge and skills,
- A well-implemented system can play a major role in the decrease of cognitive overload in students, enabling them to adopt and transfer information, when necessary, in a simpler manner.

4. DESIGNING LEARNING ACTIVITIES

The process of designing learning activities should encompass:

- An assessment of the previously adopted level of knowledge,
- Adjusting the existing teaching techniques (diagrams, advanced organization models, etc.) with the goal of simplifying the overview of information,
- Using additional multimedia forms to stimulate understanding and memory,
- Ensuring differently structured activities depending on the context and characteristics of potential users, as well as on the environment where the activity is to take place,
- Designing learning situations in terms of stimulating the activity of transferring concepts and procedures according to different contexts,
- Enabling the research, discovery, choice, and assessment of relevant information according to the unique conditions of the task at hand.

When it comes to learning interactions in the process of mobile learning, the following should be kept in mind:

- Interactions between students, teachers, experts, and the learning system itself,
- Students' need for social interaction, as well as the need to adopt information and/or skills,
- The dimensioning of a media space that is large enough for developing joint ideas, practical work, and mentoring, both between students and between a student and a teacher.

5. AUGMENTED REALITY TECHNOLOGIES IN MOBILE LEARNING

Applications that support augmented reality can be designed to respond to the educational needs of students in vocational educational institutions. As a result, not only will the students with special needs be able to access an inclusive design through an application, but all students can benefit from a good design (Bacca, et al 2015).

Applying augmented reality can be very effective with learning materials that are difficult to understand or are entirely conceptual by increasing the students' interest in the concepts of learning (Parhizkar et al., 2012). Among other things, it can provide students with an experience that is built into the learning materials that describe real situations. Using augmented reality, students can explore materials that have been shaped by a given situation or learning context. The most prominent examples have to do with the exploration of physical surroundings by topic of interest, such as history, the arts, technology, biology, astronomy, etc. (Yen et al., 2013).

The previous applications of augmented reality in the domain of education have enabled:

- Learning using 3D content, which allows students to better understand the materials,
- Comprehensive, group, and situational learning, where students connect with each other, both time- and space-wise, for better cooperation,
- A sense of attendance, immediacy, and direction,
- The visualization of the invisible elements of the learning materials, and
- Establishing a connection between formal and informal education.

6. SETTING UP THE FRAMEWORK FOR THE MOBILE LEARNING MODEL WITH ELEMENTS OF AUGMENTED REALITY

The framework in which the use of mobile devices in learning is viewed depends on the purpose of the usage of the device (research, simulation, etc.), technical capabilities for access and installation, and the level of user competencies (Alioon & Delialioglu, 2015).

Setting the framework for mobile learning based on augmented reality encompasses the definition of:

1. The model and form of learning materials that will be used through augmented reality;
2. The type of interaction between the participants and learning materials using mobile devices;
3. The context of the augmented reality application defined according to a certain model (usually identity, location, surroundings, etc.);
4. The type of learning meant for the augmented reality model in terms of individual or group work, professional training, etc.

The creation of the model primarily encompasses the definition of the necessary entities that participate in the AR-powered mobile learning process. The basic entities are students and teachers, who, along with the learning objects (course materials, printed materials, physical surroundings, etc.) make up the real-world part of the model. Virtual reality enhances the materials with an augmented context using a predefined interaction between these contents depending on the characteristics of the student. The characteristics of the mobile device enable the augmentation of reality.

The components of the mobile learning model using augmented reality include:

- The real world or the context, including all course materials, learning objects, or the environment where learning is taking place.
- Digital content or augmented context, including 3D graphics, symbols, images, explanations, etc. that enhance the real world.
- Learning activities that tie together the real-world and digital content through different interpretations, amendments, interactions, etc. (Santos, et al., 2013).

The real world implies the presence of the learning objects, students, teacher, and learning materials in different forms. Important contextual elements are the goals and tasks the teacher provides (lectures, laboratory exercises, homework, independent work, etc.).

The augmented context implies the addition and display of clearly defined and evaluated information in a multimedia format, based on the symbols of the learning objects. Adding augmented content is a form of contextual visualization, i.e., the presentation of virtual information in the context of a real-life environment. Contextual visualization can have beneficial effects on learning, since virtual information is in accordance with real-world objects, which decreases the need for attention-switching between different media. In addition, contextual visualization uses multimedia symbols in the known, real environment, which helps students manage what they're learning. Teachers are tasked with adjusting the objects and surroundings to the students' needs. Course materials can include the interface, information (text, image, or audio), and its own characteristics such as length, language, and choice of words. The information contains 3D graphic computer models and notes or symbols such as numbers, circles, arrows, etc.

Learning activities can include individual steps in the learning process using course materials, with the option to use additional study materials. The augmented reality system, based on the symbols and pre-prepared additional contents in the database, evaluates, pairs, records, and archives content. Interactivity during the use of augmented reality allows students to potentially adjust certain parameters with the goal of tracking the expected outcomes (Matsutomo et al., 2012). These adjustments are possible precisely because of the dynamic rather than static nature of augmented reality.

7. LEARNING MATERIALS IN THE AUGMENTED LEARNING ARCHITECTURE

Learning materials in the context of augmented reality architecture are educational content used to distribute learning. These materials can be digital or analog, single-use or multi-use, or they can be referred to during the learning process (IEEE standard for learning object metadata, 2002).

Creating learning materials for augmented reality requires several electronic educational resources (hardware, software, content), which include texts, audio, video, virtual 3D objects,

different forms of feedback, navigation, and instructions. Such learning materials should be easy to integrate with traditional printed publications (textbooks, handbooks, or other books). This is especially important in terms of the enhancement of the didactical effect through the implementation of various educational practices, such as the need for new training materials, consolidation of learned materials, virtual laboratory work, researching virtual models, etc. (Sannikov et al., 2015).

The identification of objects from the real world that are being used for learning is done using mobile devices. These objects are first assigned augmented reality symbols that define the name or location. Then, the augmented reality symbol is identified using a multimedia device, such as a camera, a tablet, or a smartphone. Afterward, based on the identifying information, the user can download contents from the database, which will then join real-world objects.

8. THE GOALS OF INTEGRATING AUGMENTED REALITY INTO THE MOBILE LEARNING PROCESS

The mobile learning model based on augmented reality technology can be integrated into traditional classes at any higher educational institution. The integration of this model into everyday classes, based on pedagogical methodology, has the goal to create, realize, and test new technologies for the visualization of augmented reality in the mobile environment in order to further motivate students. The goal of implementing this model has two major points:

- On one hand, technology enables an enhancement of materials beyond regular textbooks during traditional classes,
- On the other hand, the application of scientific content is implemented into the real world.

Given this, the teacher and the textbook are not completely eliminated from the learning process, but they are supplemented with new technologies based on pedagogical tools.

The mobile learning model based on augmented reality technology can pose an alternative to traditional teaching methods, where instructions can be applied simply and in real time. The saved time that's necessary to adopt new knowledge can easily be measured.

9. DISCUSSION IN THE PLACE OF CONCLUSION

The application of augmented reality in the mobile learning process allows for more efficient adoption of course materials, which is apparent in test results and the decrease in errors in work (Radosavljevic et al., 2019). Students' professional competencies and skills, as authors (Sannikov et al., 2015) explained in their works, are more easily and quickly adopted using augmented reality applications. Owing to the possibility of adjusting the materials to the user, there has been a decrease in the number of errors and an increase in the understanding of course materials (Radosavljevic et al., 2019).

References

Alioon, Y., & Delialioglu, O. (2015). *A Frame for the Literature on M–learning*. Procedia – Social and Behavioral Sciences, 182, pp. 127–135

Bacca, J., Baldiris, S., Fabregat, R., Kinshuk, & Graf, S. (2015). *Mobile Augmented Reality in Vocational Education and Training*. Procedia Computer Science, 75, 49–58. http://dx.doi.org/10.1016/j.procs.2015.12.203

Chen, N., Teng, D., Lee, C., & Kinshuk. (2011). *Augmenting paper–based reading activity with direct access to digital materials and scaffolded questioning*. Computers & Education, 57(2), 1705–1715, https://doi.org/10.1016/j.compedu.2011.03.013

Chen, P., Liu, X., Cheng, W., & Huang, R. (2016). *A review of using Augmented Reality in Education from 2011 to 2016*. Innovations In Smart Learning, 13–18. https://doi.org/10.1007/978–981–10–2419–1_2

IEEE standard for learning object metadata. (2002). New York, N.Y.

Klopfer, E., & Squire, K. (2012). *Environmental detectives: The development of an Augmented Reality Platform for Environmental Simulations*, Educational Technology Research and Development, 56 (2), pp. 203–208

Kohen–Vacs, D., Jansen, M., & Milrad, M. (2013). *Integrating Interactive Videos in Mobile Learning Scenarios*. QScience Proceedings, 2013(3), 17. https://doi.org/10.5339/qproc.2013.mlearn.17

Koole, M. (2009). A Model for Framing Mobile Learning, in M. Ally (ed.) *Mobile Learning Transforming the Delivery of Education and Training*. Edmonton, Canada: AU Press, Athabasca University, 25–51

Lin, H., & Tsai, S. (2021). *Student perceptions towards the usage of AR-supported STEMUP application in mobile courses development and its implementation into English learning*, Australasian Journal of Educational Technology, Vol. 37 No. 3 (2021): AJET - Issue 3, 88-103

Liu, Y., Holden, D., & Zheng, D. (2016). *Analyzing students' Language Learning Experience in an Augmented Reality Mobile Game: An Exploration of an Emergent Learning Environment*. Procedia – Social And Behavioral Sciences, 228, 369–374. https://doi.org/10.1016/j.sbspro.2016.07.055

Matsutomo, S., Miyauchi, T., Noguchi, S., & Yamashita, H. (2012). *Real–Time Visualization System of Magnetic Field Utilizing Augmented Reality Technology for Education*. IEEE Transactions On Magnetics, 48(2), 531–534. https://doi.org/10.1109/tmag.2011.2174208

Meek, S., Goulding, J., & Priestnall, G. (2012), *The influence of Digital Surface Model choice on visibility–based Mobile Geospatial Applications*. Proceedings of the GIS Research UK 20th Annual Conference (GISRUK 2012), pp. 125–131, The University of Lancaster, Lancaster, United Kingdom

Nandwani, A., Crane, L., Edwards, R., & Benachour, P. (2012) The magic door: Smart interactions between students and lecturers using contactless technologies, *Proceedings of the 11th Annual World Conference on Mobile and Contextual Learning (mLearn 2012)*, pp 252–255, Helsinki, Finland, 16–18 October 2012

Parhizkar, B., Obeidy, W., Chowdhury, S., Mohana Gebril, Z., Ngan, M., & Habibi Lashkari, A. (2012). *Android mobile augmented reality application based on different learning theories for primary school children*. International Conference On Multimedia Computing And Systems. https://doi.org/10.1109/icmcs.2012.6320114

Peters, K. (2007). *M–learning: Positioning Educators for a Mobile, Connected Future*, International Review on Research in Open and Distance Learning (IRRODL) 8, no 2, ISSN 1492–3831

Radosavljevic, S., Radosavljevic, V., & Grgurovic, B. (2018). *The potential of implementing augmented reality into vocational higher education through mobile learning*. Interactive Learning Environments, 28(4), 404-418

Radosavljevic, V., Radosavljevic, S., & Jelic, G. (2019). *Smart Classroom Environmental Parameters as a Parameter of Adaptive Learning.* PEOPLE: International Journal of Social Sciences, 5(2), 680-699

Sannikov, S., Zhdanov, F., Chebotarev, P., & Rabinovich, P. (2015). *Interactive Educational Content Based on Augmented Reality and 3D Visualization*. Procedia Computer Science, 66, 720–729. https://doi.org/10.1016/j.procs.2015.11.082

Santos, M., Yamamoto, G., Taketomi, T., Miyazaki, J., & Kato, H. (2013). *Authoring Augmented Reality Learning Experiences as Learning Objects*. 2013 IEEE 13th International Conference On Advanced Learning Technologies. https://doi.org/10.1109/icalt.2013.165

Sırakaya, M., & Sırakaya, D. (2022). *Augmented reality in STEM education: a systematic review.* Interactive Learning Environments, 30:8, 1556-1569, https://doi.org/10.1080/10494820.2020.1722713.

Yang, X., Li, J., Guo, X., & Li, X. (2015). *Group interactive network and behavioral patterns in online English–to–Chinese cooperative translation activity.* The Internet And Higher Education, *25*, 28–36. https://doi.org/10.1016/j.iheduc.2014.12.003

Yen, J., Tsai, C., & Wu, M. (2013). *Augmented Reality in the Higher Education: Students' Science Concept Learning and Academic Achievement in Astronomy*. Procedia – Social And Behavioral Sciences, 103, 165–173. https://doi.org/10.1016/j.sbspro.2013.10.322