Analyzing some Experiences of Augmented Reality in Higher Education

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Abstract

Augmented reality is being used in many areas of everyday life for different purposes. Currently, augmented educational resources are being included more frequently in teaching and learning experiences at all educational levels and in different areas of knowledge. This paper has focused on the survey of studies carried out in university contexts to identify their experimental characteristics and variables of analysis. The results obtained indicate, among other findings, that there are experiences conducted in different countries around the world, where the researchers measured the impact of the inclusion of augmented reality in teaching and learning processes by evaluating satisfaction, motivation and academic performance achieved by students involved in the experiences. In general, these students integrated control groups and used their own smartphones to access the augmented resources. In most cases, the researchers developed their own instruments of evaluation. Despite the recognized advantages for collaborative learning, the experiences of this type with augmented resources were very scarce.

Keywords

Augmented Reality, Higher Education, Students, Computer Supported Collaborative Learning

1. Introduction

Collaborative learning (CL) can be seen as teaching methods in which students work in small groups to help them learn from each other [1]. The technological advances occurred in recent decades allowed the CL include computational tools that facilitate collaboration, coordination and communication transforming it in Computer Supported Collaborative Learning (CSCL). CSCL is frequently applied in high education, and there are numerous studies showing their advantages. On the other hand, technological advances have changed the usual interfaces enable in systems. Resources novel such as Augmented Reality (AR), among others, have appeared. The AR was successful adopted by different areas, for example, economy, medicine, culture, etc. and in the last years, education.

The objective of this article is to present some background on developed researches to AR applied in university collaborative context. This paper is organized as follows: section 2 describes the analyzed works, section 3 shows an analysis and comparison of the same, and finally, Section 4 presents some conclusions and future lines of work.

HCI 2022: VIII Iberoamerican Conference of Human Computer Interaction, October 13-15, 2022, La Habana, Cuba
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CEUR Workshop Proceedings (CEUR-WS.org)

2. Our comparison

According to our search of experiences where AR was used in educational contexts, we obtained 26 papers. However, only those developed in higher education settings have been considered for this study. In this way, 12 papers were selected from among them and are described below.

1. Cabero-Almenara et al. [2] analyzed the impact of AR on motivation, academic performance, and satisfaction of Spanish students. The experiment involved 148 male and female pedagogical students, who used AR-enriched material from their mobile devices. The results were obtained through pre and post tests on the experimental group, applying three evaluation questionnaires linked to: motivation, product created in the activity, and academic performance. The results showed a direct positive relationship between the use of augmented resources, motivation, and academic performance. In addition, the authors highlighted the positive opinions expressed by the students regarding the use of AR in their learning processes.
2. Fombona et al. [3] analyzed the educational potential of AR through a two-phase research project. The first focused on the documentary analysis of background information. The second phase was experimental working with students from the Spanish universities. Based on the exhaustive study carried out in the first phase, the authors selected 100 educational applications based on AR that students used through their smartphones and tablets. The authors designed an evaluation questionnaire implemented through a rubric validated by experts. Students evaluated the selected applications using this rubric. The results showed interesting findings: most of them are free to use, are for individual use, are oriented to show moving objects, and are declared for educational purposes. Besides, almost 40% of them are still under development and require internet connection, and very few of them present a definition of objectives and assessment of learning achievements. Applications with adaptations for learners with disabilities are almost non-existent.
3. Akçayir et al. [4] applied AR to investigate the effects of its use in teaching in science laboratories. The experimentation was conducted using software called Metaio. The authors employed an experimental design based on a control group and an experimental group. The results obtained revealed that AR has a positive impact on students' attitudes and laboratory skills.
4. Bursztyn et al. [5] applied AR to simulate trip experiences for 874 students of five North American universities. In the experimentation the students used their smartphones and tablets. The authors used an experimental design by experimental and control group. Results showed that AR improved students' motivation and interest as well as their ability to learn.
5. Martínez-Pérez et al. [6] investigated the usefulness, potential and limitations of the use of AR in training processes in higher education, and detected the level of knowledge present in Spanish university students about the use of AR. The students participating in this study used Blippa and Aurasma to create their own augmented resources, in some cases working individually and in others in groups. The authors developed a questionnaire that was answered by 186 students. The results highlight the innovative, fun, challenging and playful character of AR as a resource applicable to teaching and learning processes. In addition, the authors highlight the importance of training teachers not only pedagogically, but also technologically, and the need to generate new products suitable for people with disabilities (visual, hearing, etc.).
6. Hernández-Moreno et al. [7] applied AR in a university financial mathematics course to assess students' motivation, performance, technology acceptance and prototype quality. The authors used an experimental design with experimental and control groups. The experiment involved 103 Mexican students using their smartphones and tablets. The prototypes were developed with Vuforia and Unity 3D. The experimental results showed that AR improved students' motivation and learning performance.
7. Södervik et al. [8] designed an AR-assisted learning environment to investigate the impact of AR on pharmacy student learning in science laboratories. The authors employed an experimental design based on control and experimental groups. Besides, they developed a questionnaire to measure the usability of AR-environment. The experiment involved 16 Finland university students wearing AR glasses (Vuzix AR Glasses). The results showed that AR had a positive impact on the students' performance compared to traditional laboratory instruction and prevented most errors.

Students felt that AR guided them in carrying out their activities and was beneficial to their learning. On the other hand, the authors found no differences between the groups in relation to knowledge comprehension.

8. Triviño-Tarradas et al. [9] applied AR to assess its impact on students' motivation. The experiment involved Spanish university students using smartphones, tablets, personal computers, and virtual reality glasses. The authors developed and used a questionnaire to survey students' opinions about the instructional materials and related motivational aspects such as attention, relevance, confidence, and satisfaction. The results obtained using a 5-point Likert scale showed that AR significantly improved students' motivation and understanding. Besides, most students expressed their appreciation for the use of virtual reality glasses.
9. Mendoza-Morán et al. [10] carried out their work in two stages, first they surveyed mobile educational and collaborative educational applications, both with AR. Then they developed a collaborative application that included AR. The Spanish university students involved in the experience used their mobile devices. The authors do not describe their data collection instruments, nor do they provide details about the experience with real students. The authors expressed that AR applied to education helps to understand abstract topics that need broad imagination. Besides, they claim that collaborative applications with AR allow students to learn new topics while sharing information with others in the group and that the intervention of the group members in addressing the topic with group ideas or explanations generates the possibility of achieving a better cognitive level than working individually.
10. Naese, J. et al [11] applied AR at a North American university to teach the operation of analytical instruments specific to chemistry courses. The authors developed their application using Aurasma. The created application was used by students with their smartphones. The authors do not describe their data collection instruments. However, the authors claim that AR is positive in this type of experience, as it allows students to see the components of each instrument up close, prevents them from breaking them and helps them to understand the concepts being discussed. Although students were satisfied with the use of AR, they also indicated that they prefer to have a detailed document that they can access at any time and not only when they are in the lab, as is the case with these augmented resources.
11. Urs-Vito, A. et al. [12] used AR to compare the impact on learning of having more realistic materials than traditional textbooks. The authors also investigated whether the use of AR provoked negative emotions or irritation in students. The experiment involved German undergraduate medical students. The authors developed their application using mARble software. The students used this application with their smartphones to analyze injuries in their forensic medicine classes. The authors used an experimental design based on control and experimental groups. The students answered questionnaires developed by the authors. The results showed that AR had a significant cognitive improvement and a positive emotional impact on the students.
12. Barraza-Castillo et al. [13] developed a novel framework to create a mobile augmented reality application. The framework was tested to explain the concept of a quadratic function to Mexican universities students. The authors developed the application using Vuforia and Unity 3D. The students involved in this experience used their smartphones. A questionnaire was designed by the authors as result of different interviews with several mathematics and physics professors. This questionnaire was answered by 59 students. Although more than 85% of the students had never used augmented reality before, most of them expressed their satisfaction with the experience and expressed that the virtual environment better represented the concepts previously explained by the teacher. The results showed that the use of AR can help enhance the teaching and learning processes.

3. Analysis and results

To make the comparison between the different studies of AR applied in university experiences described in previous section, seven questions were raised: 1- What kind of experience was? (Real or simulated), 2- Country where the experience was made? 3- Are there experimental results? (Detailed or brief), 4- Are there instruments designed to collect experimental data? (Questionnaires, interviews, etc.), 5- The used software by authors to create augmented resources was indicated? 6- The required hardware was indicated? 7- Are there small groups of students involved? (Collaborative or individual experience).

Considering the first question, we can say that all the studies analyzed involved the participation of real students. Considering the second question, we can say that 5 experiences were made in Spain [2, 3, 6, 9, 10], 2 in USA [5, 11], 1 in Finland [8], 2 in Mexico [7, 13], and 1 in Germany [12]. Considering the third question, we can say that all the experiences analyzed show and analyze experimental results but with different level of details. Considering the fourth question, we can say that most of the researchers developed their own questionnaires to collect opinions about the experience and the application used. In general, the approach applied was by post-test in control group. Considering the fifth question, in most of the analyzed papers the software application used was described [4, 6, 7, 9, 11, 12, 13]. Considering the sixth question, the situation is similar, several researchers described their hardware requirements, and the more frequently used resources were smartphones and tablets. Only, in two cases, there are not such information [4, 6] but the authors say that students used mobile devices. Finally, considering the seventh question, we can say that only two experiences were made around a collaborative proposal [6, 10]. In [2, 3, 4, 5, 7, 8, 9, 11, 12, 13] the students performed their activities as individual proposals. In Table 1 the questions and answers are synthetized.

Table 1
Characteristics of experiences analyzed

#	Real Students	Country	Analysis included	Tests	AR-Software used	Hardware used	Colab.
1	Yes	Spain	Brief	Pre/post-tests (questionnaires)	-	Smartphones, Tablets	No
2	Yes	Spain	Extended	Post-test (questionnaires)	-	Smartphones, Tablets	No
3	Yes	-	Extended	Pre/post-tests (questionnaires)	Metaio	-	No
4	Yes	USA	Brief	Pre/post-tests (questionnaires)	-	Smartphones, Tablets	No
5	Yes	Spain	Brief	Post-test (questionnaires)	Blippar, Aurasma	-	Yes
6	Yes	Mexico	Extended	Pre/post-tests (questionnaires)	Vuforia, Unity 3D	Smartphones, Tablets	No
7	Yes	Finland	Extended	Pre/post-tests (questionnaires)	-	Vuzix AR Glasses	No
8	Yes	Spain	Extended	Post-test (questionnaires)	Sketchfa, WebXR	Smartphones, Tablets, PC, Lens 3D	No
9	Yes	Spain	Brief	-	-	Smartphones, PCs	Yes
10	Yes	USA	Brief	-	Aurasma	Smartphones	No
11	Yes	Germany	Extended	Pre/post-tests (questionnaires)	mARble	Smartphones	No
12	Yes	Mexico	Extended	Post-test (questionnaires)	Vuforia, Unity3D	Smartphones	No

4. Conclusions

In many areas of science and industry the AR is being applied successful. The education is not an exception, and this is demonstrated by the 12 university experiences analyzed in this article. The universities involved were from different countries in America and Europe, many of them in Spain. All experiences included in this study were developed with the participation of real students integrating control groups. Each one experiences presented the results in different level of detail, but all included several variables of analysis. In general, the experiences were evaluated with questionnaires designed by the authors. All papers described the software and hardware resources used. In general, don´t exist coincidences between the software applications used. Besides, considering the hardware, the smartphones were the most used resource. Considering the proposed analysis variables, the most used were satisfaction, motivation, usability, and academic performance. No research presents an analysis of learning objectives and achievements achieved with the use of AR. In all cases, students react positively to the inclusion of AR resources in their learning process. Unexpectedly, despite the recognized advantages associated with CSCL, AR experiences that included collaboration were only two.

According to these findings, the authors of this article are currently working to develop AR-based collaborative experiences with university students of Computer Sciences where learning objectives and achievements will be carefully defined.

5. References

[1] Barraza-Castillo, R., Cruz Sánchez, V., and Vergara Villegas, O. A Pilot Study on the Use of Mobile Augmented Reality for Interactive Experimentation in Quadratic Equations, Math (2015).

[2] Cabero-Almenara, J., Fernández-Robles, B., y Marín-Díaz, V. Mobile devices and augmented reality in the learning process of university students. RIED. Revista Iberoamericana de Educación a Distancia, 20(2), 2017: pp. 167-185. doi: 10.5944/ried.20.2.17245.

[3] Fombona, J.; Pascual, M.A. y Vázquez-Cano, E. Augmented Reality: A New Way to Build Knowledge. Bibliometric Analysis and Apps Testing. IEEE Revista Iberoamericana de Tecnologías del Aprendizaje, RITA 15.1, 2020: 17-25. doi: 10.1109/RITA.2020.2979167.

[4] Akcayir, M.; Akcayir, G.; Pektas, H.; Ocak, M. Augmented reality in science laboratories: the effects of augmented reality on university students´ laboratory skills and attitudes toward science laboratories. Computers in Human Behavior 57, 2016: 334-342. doi: 10.1016/j.chb.2015.12.054.

[5] Bursztyn, N., Brett, S. Walker, A. Pederson, J. Increasing Undergraduate Interest to Learn Geoscience with GPS-based Augmented Reality Field Trips on Students' Own Smartphones. GSA Today. 27.6, 2017: 4-10. doi: 10.1130/GSATG304A.

[6] Martínez-Pérez, S. Fernández-Robles, B. Barroso-Osuna, J. La realidad aumentada como recurso para la formación en la educación superior. Campus Virtuales 10.1, 2021: 9-19.

[7] Hernández-Moreno, L. López-Solórzano, J., Tovar-Morales, M. Vergara-Villegas, O., Cruz-Sánchez, G. Effects of using mobile augmented reality for simple interest computation in a financial mathematics course. PeerJ Computer Science 7:e618, 2021. doi: 10.7717/peerj-cs.618

[8] Södervik, I., Katajavuori, N., Kapp, K., Laurén, P., Aejmelaeus, M., Sivén, M. Fostering Performance in Hands-On Laboratory Work with the Use of Mobile Augmented Reality (AR) Glasses. Educated Science 11(12), 2021: 816. doi: 10.3390/educsci11120816.

[9] Triviño-Tarradas, P., Mohedo-Gatón, A., Hidalgo-Fernández, R. Mesas-Carrascosa, F. Preliminary results of the impact of 3D-visualization resources in the area of graphic expression on the motivation of university students. Virtual Reality, 2021. doi: 10.1007/s10055-021-00606-2.

[10] Mendoza-Morán, V., Rivera-Richard, J. Barriga-Andrade, J. Sistemas de Aprendizaje Colaborativo Móvil con Realidad Aumentada. Revista Politécnica 38(1), 2016. . URL: https://www.academia.edu/44303988/Sistemas_De_Aprendizaje_Colaborativo_M%C3% B3vil_Con_Realidad_Aumentada

[11] Naese, J., McAteer, D. Hughes, K., Kelbon, C., Mugweru, A., Grinias, J. Use of Augmented Reality in the Instruction of Analytical Instrumentation Design. Chemical Education 96, 2019: 593−596. 2019. doi: 10.1021/acs.jchemed.8b00794.

[12] Urs-Vito A., Folta-Schoofs, K., Behrends, M. von-Jan, U. Effects of Mobile Augmented Reality Learning Compared to Textbook Learning on Medical Students: Randomized Controlled Pilot Study. Journal of Medical Internet Research 15.8: e182, 2013. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3758026

[13] Barraza-Castillo, R. Cruz-Sánchez, V. Vergara, O. A Pilot Study on the Use of Mobile Augmented Reality for Interactive Experimentation in Quadratic Equations. Mathematical Problems in Engineering, Article ID 946034, 2015. doi: 10.1155/2015/946034.