Augmented Reality as a Technological Solution in the Teaching/Learning Process in Civil Engineering Course Classes: a Case Study

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***Abstract* - This paper is about the use of Augmented Reality (AR) in civil engineering classes at Federal Institute of Education, Science and Technology, Palmas, Brazil. It considers that AR is an expanding technology that is already used in some areas and can also be applied to education. AR can provide support for the teaching/learning process provided to the student through visualization and manipulation since learning improves when one sees what is being explained in a dynamic image. This kind of technology adds information and improves the current educational environment. This article proposes a solution with an application to assist teachers, more specifically concerning an undergraduate course in civil engineering.**

Keywords-Technology; Telematics; Augmented Reality; Civil Engineering; Education.

I. INTRODUCTION

Traditional methods are still used for teaching students in most universities, colleges and schools around the world. However, those methods have proved to be insufficient, considered in terms of their efficiency [1]. Students want a more dynamic approach in the classroom and this is possible with the use of technology. Augmented reality can be used to bring a new approach to a class, making it a more an exciting experience.

This research focuses on the challenge of developing an application with the use of AR as a contribution to expanding the concept of learning from theoretical to practical experiences. The purpose of the application developed is to serve as a teaching material resource for teachers to assist them in their classes and allow the students to empirically explore some key concepts of the Basic Sanitation I and II classes, which are undergraduate courses in civil engineering and as a proof of concept regarding the efficiency of augmented reality use in the teaching/learning process.

In this work we present an easy way for developing augmented reality solutions, without the need to know computer programing. We then introduce the AppSheet tool as the means for doing that.

II. RELATED WORKS

We will present in this section, some works that use the Google Appsheet as an easy way for developing solutions involving database and cellular applications, in order to demonstrate the real importance of the Google AppSheet tools for facility the development and database operation. Currently, technology is being used to offer ubiquitous information solutions for all areas and problems. Mobile devices provide a fundamental contribution in this process of disseminating information. Magalhaes et al. [2] also presented the use of a mobile application, created using an Open Source tool, to complement the teaching of music in second-year high school classes. The authors have demonstrated the improvement in student results, through implementing classes with the use of this tool and with subjective evaluations provided by students.

In this regard, Manoel [3] claims that cell phones and tablets are more common than TV sets nowadays, and there are, on average, four mobile devices per person in a middle-class family.Santos et al. [4], on the other hand, show that mobile applications can be applied in environmental preservation areas. To this end, the authors developed an application that generates a kind of social network where anyone can check to see if there is some triggering event, spontaneous or caused by human activity, which is compromising rivers, forests, etc. The application can take photos of the event and send them to the network in real time and with the exact location, public agents can act.

Based on these numbers, Moreira [5] presents a solution to complement the teaching of mathematics at the elementary school level, with the use of a mobile application. According to the author, the use of this application in mathematics classes, aided by the fact that all the students have a mobile device, has made school more attractive for students, since all of them focus more on exercises, knowing that the answers will be provided by cell phones and ranked as if in a game.

Mobile applications are also being used to streamline administrative procedures. This was proposed in Martins et al. [6], where with the help of a mobile phone, teachers in the city of Palmas, Tocantins, can have quick access to the result of a national student ranking test, called "Provinha Brasil", that shows indicators of use of learning in Portuguese Language and Mathematics courses. These indicators provide important information so that teachers may respond within the same school year, using methodological innovations to help students make up their deficiencies.

Therefore, in order to continue to encourage the use of mobile applications for resolving problems with the help of mobility, this research presents the construction of a mobile

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application that uses AR as a tool for assisting teachers in their classes.

III. PROPOSAL

According to Brighenti et al., even if students study for a long time, this may not be enough for them to adequately understand the topics presented by the teacher/professor. That happens because many students do not interact with the teacher in the classroom. Because of that, interaction with a teacher is probably the best way to encourage students for effective participation in or out of the classroom. The application of technology for improving availability of data content in the classroom can be a step towards improvement over the traditional methodologies.

Given that technology is currently present in various areas and that advances in information technology are changing the lives of everyone, it is necessary to include IT in educational processes. It is possible, with the use of AR, to improve some methods or methodologies in the teaching-learning process used in the classrooms.

Civil engineering is an area that requires considerable work from teachers and students. Technological resources may bring more interaction in the classroom and may make the classes more attractive. The possibility of viewing objects in 3D and interacting with them, can provide teachers and students with a new experience in the learning/teaching process.

This paper proposes the development of a solution to assist undergraduate course teachers in improving the reality of the teaching/learning process and its objective is to assist the education professionals involved in teaching in the state of Tocantins with this technology tool. The case study proposes to support teachers in the civil engineering course with a case study in Basic Sanitation classes. This solution can aid professors of any area, through the use of technological resources that enable collaboration that can help students to shorten the distance between theory and practice in the classroom through information technology.

Below is an image that graphically explains the flowchart of the solution. Figure1.

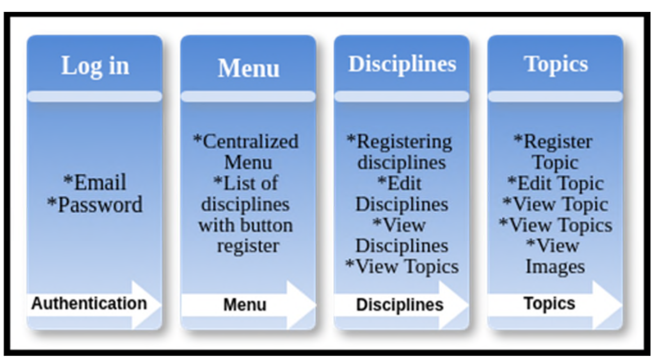

Figure 1. Solution Flowchart.

As seen in Figure 1 above, the screens are being presented, i.e. the modules of the proposed solution. The Minimum Viable Product (MVP) has a login screen, a course menu, and a menu of topics. Users will be able to access these screens with a few clicks and thus access the content provided by the teachers. The application has two levels of access: Administrator level for teachers to manage content and Default level for users accessing digital files via mobile device.

A. Materials

The materials used to develop the MVP, the prototype called AR applied in civil engineering (S.C.A.T.) used the AppSheet [6] tool of Google [7] that is simply software in a Web platform that enables the development of mobile device-independent devices in a simple and dynamic way.

Not only does the AppSheet stand out due to its practicality and agility in the development of mobile applications, but another striking quality in this software is it's the integration with the free Google tools, notably Google Drive [8] used for storing data and application information. In this scenario, Google Sheets [9] were used as a database to store application settings and data during development and testing.

During the construction of the MVP the laboratory of the graduate course in Telematics of the Federal Institute of Tocantins was used, where the implementation of the tasks proposed by the group and the use of the tools cited above were also done. Computers (desktops) in the Telematics laboratory were used during the classes as well as personal smartphones of the researchers with IOS and Android operating systems. All those tools guaranteed that the content produced during the work was safe and available at any time, in the cloud. Below is the list of materials used in this research:

- Desktop computer with Linux operating system Ubuntu version 16.04 LTS.
- Personal email accounts, Gmail [10] email provider, from survey participants.
- For the construction of application usability validation forms, Google Forms [11] was used, due to its practicality in sharing with respondents.
- To produce the application flowchart, the software was used on a web platform called Cacoo [12].
- To test the prototype, the personal smartphones of the researchers were used, these being: a 5s from Apple with operating system version 11.2.6 and J5 of Samsung with operating system version 6.0.1.
- For dissemination and sharing of the link to forms, social networks were used: Facebook [13], Instagram [14], Twitter [15] and WhatsApp [16], with the aim of involving a larger number of respondents.

B. Methods

This Section will present the methodology used in the solution proposed in this article. The research was developed in the Graduate course in Telematics. The work of the research group consisted of meetings in the Computer Science Laboratory of the Federal Institute Palmas campus, alternating with some virtual meetings. According to Magalhaes et al. "since the course uses Problem-Based Learning (PBL) methodology, the first part of each meeting

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was dedicated to solving problems that were presented to the research group by a tutor. The second part of the meetings was dedicated to the search for solutions."

For virtual meetings the research group used tools such as YouTube [17], WhatsApp, Gmail, Hangouts [18], Docs [19], Sheets, Slides [20], Forms, and Overleaf [21]. In order to provide students and teachers with technological tools to support the process in the classes using information technology, much of the research was dedicated to creating an application as a solution capable of providing content such as high-quality images, related to civil engineering in digital formats available in the cloud and accessible through mobile devices such as smartphones, regardless of the operating system of the device.

A review of the literature was first carried out to assemble the necessary requirements for development of the Augmented Reality in Civil Engineering (RAEC) application, with an emphasis on learning and assimilation of content.An MVP was created, which is simply a version of the application with the minimum possible features, but that maintains the essence and all the features proposed for the application. During application development the research group was guided by a tutor in the process of developing the initial and other test versions.

To develop the application with the AppSheet tool, three electronic spreadsheets were used that contained data to model, create the tables and serve as a database for the application. During construction of the project Programming Object Orientation (POO) techniques were applied to create the tables of courses, topics and menus, since the configuration of the AppSheet tool for the display of contents was inherited from the experience of researchers in the area of programming and software development.

After creating the application database through the worksheets created by the research group, these were imported into the AppSheet tool, assuming that the tool allows creation of an application in three ways, namely: building an application from examples set by the tool itself, from a blank template or from existing data in spreadsheets. The research group chose the third option. After choosing which option to follow, it was necessary to inform the name of the tool and the application category. The initial functions of the application are: Add, edit and delete.

Soon afterwards, the authors began working on the flow that users would use to have access to the content that the application would provide. To create the flow the authors used the Cacoo tool mentioned in the previous section. After discussing and drawing the flow of application functionality and navigability, the research group began the application design improvements, that is, the authors began to insert pertinent to the civil engineering course; the researchers also put in buttons and icons, changed the standard fonts of the texts and customized Application default messages.

For the testing phase of the application, when implementing the functionality of the application, in order to make all the necessary configurations in the tool for the perfect functioning of the prototype the researchers had to enter the App Stores of survey participants' smartphones and install the AppSheet application to have access to the project developed. Fictitious data were thus removed and then data such as the course name were added to the main screen of the application, along with the courses and all the information in the fields created in modeling the tables. These courses served as the case study.

Tests of the application were carried out by all the students and the faculty of the Graduate course in Telematics and participating friends of the researchers; the tests were necessary for the prototype to obtain contributions of opinions, suggestions and criticisms so that the Group could have the chance to analyze possible improvements and functionality of flow and design in the application. The application was tested by more than 40 people who contributed to the advancement of the proposed solution.

IV. RESULTS

A public opinion survey was carried out with the students in the graduate course on usability improvements and navigability of the prototype for the proposed solution with the research presented in this article and the results obtained through the preparation of five questions with an emphasis on usability and navigability, with each issue containing ten alternatives, on a scale of one to ten. With this research, it was possible to create an MVP version of the proposed application and this version went through several tests to analyze inconsistencies in the project, including tests on multiple platforms.

With this research the research group attempted to extract information that would add value to the design of the application as well as enable the navigation flow so that people could conclude an activity in a few steps and thus have rapid access to the contents available in the application. Below is the graph with results obtained from applying the questionnaire. The questions applied were: Did you encounter any difficulty in navigating between the screens? Regarding usability of the application, can you easily identify what screen it is on? Has the application adapted to the screen size of your Smartphone or Tablet? Can you identify what kind of application this is?

For the first question, according to Figure 2 we obtained a percentage of 77.8% replying "yes," while 22.2% replied "no."

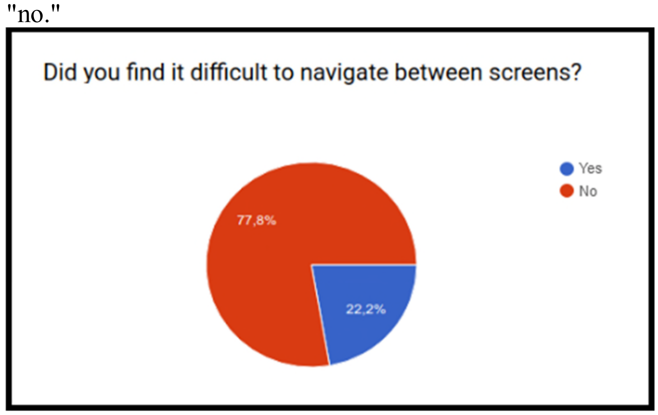

Figure 2. Graph with the answers tothe first question in the form.

The graph in Figure 2 presents the result of the answers obtained from the first question applied in the design evaluation questionnaire for the RAEC application to measure the navigability of the prototype on the different screens of the application This result was considered satisfactory by the researchers, because the App is still in the early stages.

For the second question, according to Figure 3 the results were that 90% answered "yes" to question two, while 10% of the answers obtained in question two were "no."

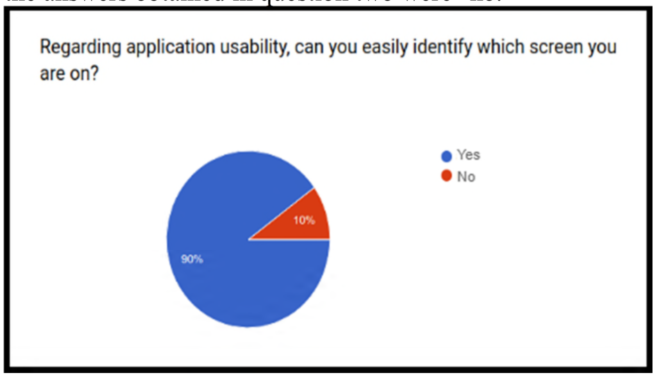

Figure 3. Graph answers to question two.

Figure 3 shows the percentage of responses obtained through application of questionnaire, question 2, to evaluate the usability design of the application; the results were satisfactory for the researchers because 90% of the people who answered the questionnaire said they were able to easily identify which screen they were on.

In question 3, the goal was to analyze the application's adaptation across multiple smartphones and platforms. According to Figure 4, the results were that 100% of the people who tested the application said that it adapted as expected.

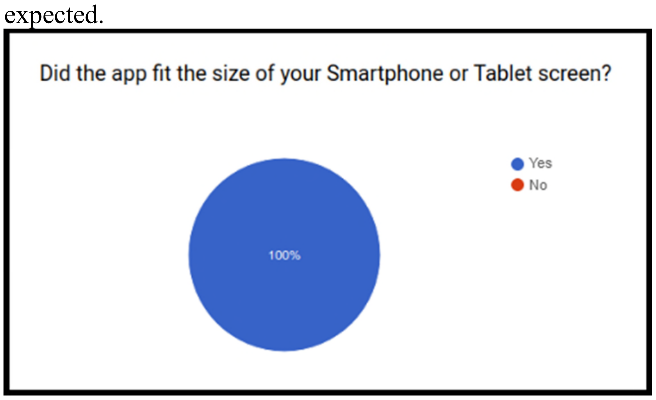

Figure 4. Graph with the answers to question 3.

In Figure 4, the graph is used to present the results acquired by applying the questionnaire. Question 3 evaluated the behavior of the application, and the answers indicated that the software was adapted perfectly in different types and screens of mobile devices.

For the fourth question, according to Figure 5 a total of 77.2% answered "yes" to question 4 and 22.2%, replied "no." This is a positive point for motivating researchers to follow up on the research. That is because the App is still at an early stage. Nonetheless, 77.8% of the people who answered the questionnaire affirmed that they were able to identify the application.

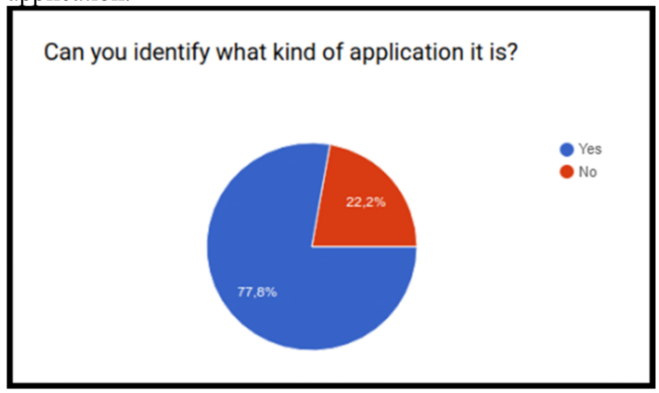

Figure 5. Graph Graph with the answers to question 4.

The graph presented in accordance with Figure 5 shows the result of question 4 used to evaluate whether the people who tested the prototype were able to identify what type of application was being used, and once again the result was satisfactory for researchers.

For the fifth question, according to Figure 6 we obtained a total of 90% "yes" answers to question 5, while 10% replied "no."

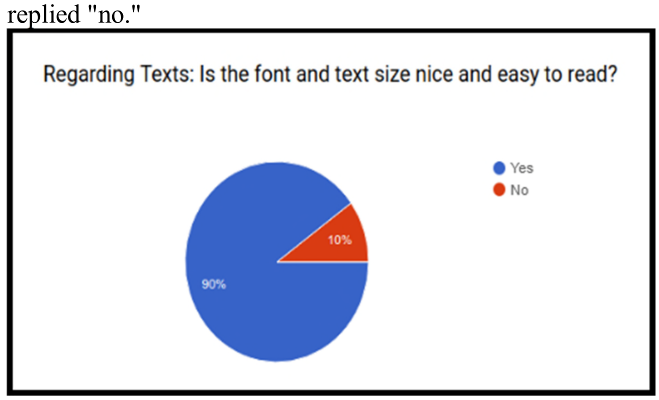

Figure 6. Graph with the answers to question 5.

According to Figure 6, the graph presented above shows the result of question 5, which elicited information as to whether the texts: fonts and sizes of the texts had a pleasing appearance and were easy to read by users who tested and responded to the Questionnaire. The graph shows that 90% of people answered positively.

A. *Expected Results*

The MVP developed by researchers provides all the features proposed for the final version of the application that will be used by teachers of Basic Sanitation I and II of the civil engineering course, except that the use of augmented reality increased the presentation to an hour, with static images presenting the topics to be addressed by these project courses.

For better contextualization of the features proposed by the application developed by this research group follows the screenshots of the main application screens.

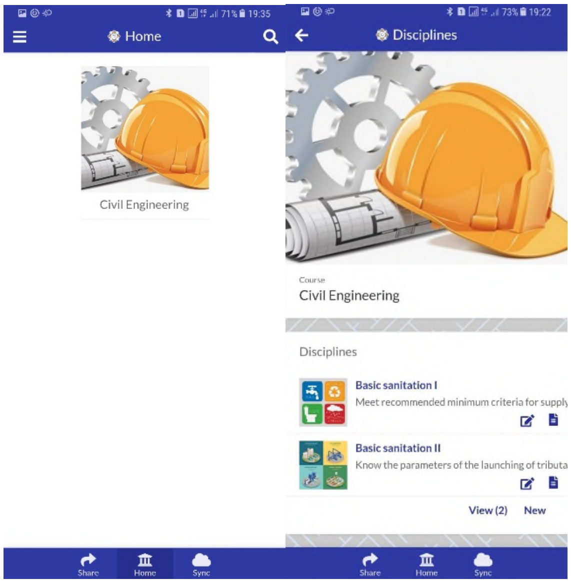

Figure 7. Home screen and screen listing courses.

According to Figure 7, the prototype has several screens: the first image of Figure 7 is the main screen, that is, the home screen for the app. When any user of the app is accessing it, the software will start on this screen. The second picture in Figure 7 is the course menu screen after the user has passed the main screen and selected the course to be consulted. On this screen the user can choose which course to access and verify the details of the chosen course; the user can also edit or add a new course.

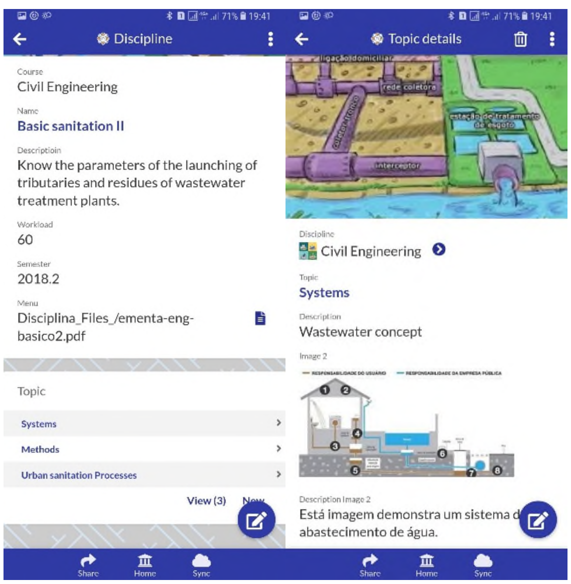

Figure 8. Screen details of the courses and screen listing topics.

When accessing a specific course, the user will have access to the details of the course, in addition to adding a new topic and accessing any of the topics covered by the course, according to the first image of Figure 8. When selecting a topic, the user can view the information that is available for this topic and also edit it.

The expectation of the research group is that the final version of the application will have all the functionalities presented in the above figures, along with the implementation of a new functionality that will utilize augmented reality technology. That functionality is added in the second image of Figure 8, and with this new functionality users can point the camera from their mobile devices to a bookmark that will display virtual images on their device that can be manipulated by users.

V. Conclusion and Future Work

The authors believe that information technology can continue to make major contributions to education; this has been demonstrated over time with the use of multimedia resources used in the classroom. Newer technologies, such as microcomputers, smartphones, and tablets must also be used in the classroom. It is in this sense that the research reports presented in this article show that the authors believe that technology can change the teaching-learning scenario. Based on the research, the authors believe that with the use of technology in the classroom it is possible to more quickly identify the weaknesses of each class or even of each student in using technological resources.

This prototype mobile application focuses on being a tool towards a solution for educational problems than can assist the teacher and the students in the classroom in a more intuitive, faster and effective way. It is worth pointing out, therefore, that there is a need to invest in education technology. In light of that, the expectation of the researchers is that this prototype can be tested in the educational environment and provide contributions to professionals for possible improvements and thus become a useful tool with more updated versions.

However, some obstacles still exist: the lack of financial investments in Brazilian schools for research and implementation; difficulties in access to new technology by the students; and of course, integration of AR as proposed in our research. To that end, further research will be needed on the subject and new implementations will remain to be dealt with in future work, so that they can provide the expected results being empirically tested in the classroom.

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