AUGMENTED REALITY TO SUPPORT 3D VISUALIZATION OF GEOMETRIC ELEMENTS IN CLASSROOM WITH AR TEACHER TOOLS

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ABSTRACT

The augmented reality technology has too many direct applications for different areas. However, some contexts are more likely have particular possibilities to improve teaching techniques, and consequently, improving the quality of learning. Our approach consider a specific scene, where a teacher exposes visual content to his class, thus, the model itself helps not only understanding the 3D objects, but also the teacher's analysis. Aiming to bring an alternative concept in teaching people based on a tri-dimensional environment analysis, the teacher applies this idea of learning to classroom context, through the use of portable devices such as tablets and smartphones.Superimposing augmented reality content previously built from drawings may help improving the students understanding in migrating from 3D augmented environment to the real 2D environment.

Keywords: Classroom Learning; 2D and 3D Augmented Environment; Augmented Reality.

1. INTRODUCTION

This article describes a method of improving learning process with use the augmented reality in the classroom. The technology evolution made possible the use of new techniques and tools to support development and understanding inside classroom. The 3D view capability is the main skill of basic perception to recognize and understand objects of the physical world (Salkind 1976).

This work aims to help and stimulate the spatial view learning of students of elementary school. The geometric thinking is an ability that must be practiced during academic course. The previous researches indicate that students young in the most different thinking levels, they perceive geometric shapes differently (Clement and Sarama, 2000; HO, 2003; Wu and Ma, 2006). Some people has difficulty in transfer geometric figures from 2D plan-to-plan 3D and they needs get more domain of 3D geometry, inside classroom. The augmented reality models works dynamically, approximate the student to understand the solid, perspective and their projections.

The traditional method to learn spatial view is to do the elementary students to analyze and compare points from bidimentional views (2D) and design to tridimentional plan (3D). Furthermore, those methods has limited use to the conceptual struct due the interaction shortage between the reader and visual images, such as images, during the formation. Moreover, the elementary students cannot meet customers satisfactory acquiring spatial ability to the learning and representation of object volums. In this case, many students had difficulty to conceptualizing 2D images to 3D design for plan, still in the graduation. The teachers must provide a learning experience, which stimulate an ability and understanding of the geometric shapes by childrens in classroom.

The research presented in this paper makes use of Augmented Reality (AR) to develop ability the spatial view of students in the classroom. Through of Augmented Reality, students can analyze object in details, thus him can rotate the object and inspect your different angles. The virtual model stimulates multiple senses the student and provides a connection to understanding between the 2D representation and their spatial representation. Thus, there is great potential to build teaching models that incorporate this technology into the classroom (Kaufmann, 2003; Weghorst 2003).

The research was experimented by elementariness students group. Initially, the students were submitted to perception and capacitation tests without using aids tool. After, making use our support tool, AR Teacher Tools, students were able to measure and understand the purpose of the tests faster. Through this analysis, we evaluate the results generated by the students, and de-emphasize the significant improvement by adopting the support tool. From the developed models and the application of the tests, it was possible to measure the the degree of improvement, to its ability to display 3D objects.

Our research is in an AR tool, developed by our team in LAMCE/GRVA Laboratory in COPPE, which aggregate the lot area from knowledgement until actually. We will mapping the children group for two scenarios, before without our tool, and after making use our tool, and measuring an improve them and their capacity to view 3D objects. This tool can be used in many areas as the visualization can help understanding and interpretation. Our goal is to achieve undergraduate peoples for the scenarios with and without the use of **AR Teacher Tools.**

2. METHOD-TANGRAM

Our study deals with the use a Chinese puzzle consisting of seven pieces, which can form many different figures. The pieces of the puzzle were modeled in 3Ds Max and placed in the library of AR Teacher Tools. The tool provides the seven volumetrically modeled parts and encourages the construction of figures helping the development of logic, intelligence and imagination. The intention is to stimulate and sharpen the development of spatial vision.

3. METODOLOGY

The research investigates the process of evolution and effectiveness of learning using the AR is teaching and developing space vision. Within the classroom environment, students were tested in two steps; (1) Use only the traditional 2D images study and (2) use of the AR with the 3D object. To validate our study developed an intuitive and interactive tool to assist the representation of 3D models.

4. TOOLS

The support tool is an application for mobile devices, such as Tablet, Smartphones, and so on, that has some models divided into levels of difficulty, as shown in Figure 6. The idea is to provide a simple interface to be handled and practice to promote the understanding by anyone on their level of cognition. The interaction between the user and the tool is, basically, the touch screen of the device.

The tool has experimentally fifteen simulations Tangram. Fourteen of these simulations have a silhouette to be mounted by the Tangram pieces and a simulation that has no silhouette, i.e. this is the simulation of freestyle.

4.1. DEVELOPMENT

The application was developed using the Unity 3D Game Engine version 5.0.1, with working scripts written in c # (C-Sharp). For the inclusion of the augmented reality (AR), we use the framework of the Vuforia. Tangram parts were modeled in 3Ds Max program.

The application was tested on three mobile devices, a Tablet Galaxy S3, with 4 GB RAM and Android version 4.2.2 (Jelly Bean) in a Galaxy Tablet Note 12.1 with 8 GB RAM, 4.4.3 and Android on a Smartphone Z3 Compact Sony, Android version 4.4.4 (Kit Kat). Application performance was excellent in all devices, that is, different capacities of Hardware does not interfere in the proper operation of the program. Besides the production of the tool and your goals, we had even the concern about the minimum hardware requirements, to use in devices that have greater compatibility.

4.2. REPRODUCIBILITY

Initially it is necessary to install the application AR Teacher, downloaded by clicking the icon. After that, any model must be chosen from those listed in the menu on the left. To be chosen, and after the recognition of the marker by the camera, the pieces that make up the template along with your silhouette appear arranged on the screen in order to be moved to its correct position, i.e. on the silhouette. The Assembly ends when all pieces form the figure of the model chosen, when that happens a message will automatically be displayed to inform the user.

The application can be replicated and validated by anyone, to do so, simply send us an email requesting the test kit. The kit is composed of the validation tool AR Teacher, a marker and the questionnaire applied. In this way, just install the application on an Android device with version 4.2.2 or higher, codenamed Jelly Bean, run it and test the models embedded in the tool.

4.3. DESCRIPTION TOOL

This section describes the screens and the features of the support tool. Highlighting the clickable areas and parts, in addition to the interaction events that may occur.

4.3.1. MAIN SCREEN

Figure 1 shows the main screen of the tool, it has a scrollable menu left aligned with the thumbnails of the Tangram. Next to this menu, is the Tangram model chosen to be mounted. In the lower right corner, there is an icon that opens the tool settings screen figure 2. If the user press the "back" button of the device, the application is terminated.

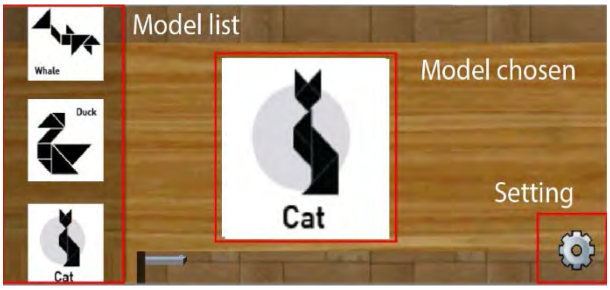

Figure 1-the AR tool main screen Teacher

4.3.2. SETTING

Figure 2 illustrates the settings screen of the tool, it contains a text field that must be filled with the location that the user wants to save the photos that can be captured when the last model of the list was selected, this is the free style, i.e. no silhouette to be filled. If the user press the "back" button of the device settings screen closes and the main screen will open.

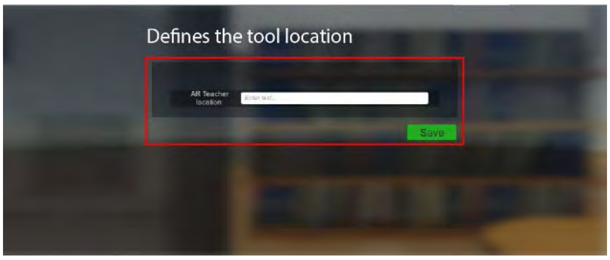

Figure 2-AR Teacher tool settings screen.

4.3.3. ASSEMBLY OF THE TANGRAM

Figure 3 represents the most important screen of the tool where students must move the pieces and fit them on the correct position in silhouette. The parts can be moved simply by simple drag n ' drop, i.e., simply click and drag the pieces around the screen, three-dimensional behavior is natural and always will exist in this environment. Another functionality is the rotation for the vertical axis (y-axis), for this, the user must hold down the desired piece and with a second touch, another finger, perform vertical movements, up or down, that gives the rotation of the piece. The two images below, Figure 3 and 4, were captured during the same simulation, however, the image 3, the device was on the marker, i.e. at an angle close to 0° (0π rad), in Figure 4, the device was almost vertical position, with close to 75° (5π /12 rad), so it can be observed the perspective view. If the user press the "back" button, then the main screen of the application device opens, and the simulation is terminated.

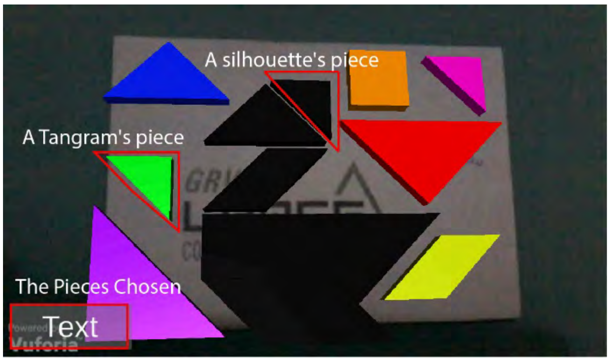

Figure 3 – mounting a screen model, top view.

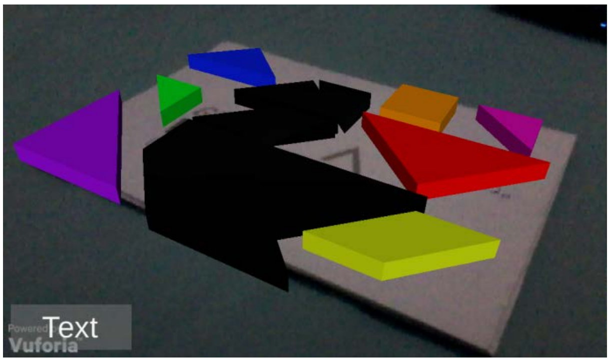

Figure 4-mounting a screen model, perspective view.

Figure 5 shows the mounting screen in free style, i.e. in this simulation, the student is free to assemble the figure of his imagination. In this section shall be measured the dexterity and creative capacity of students.

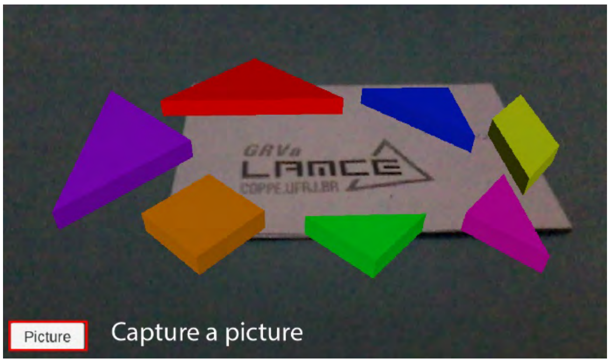

Figure 5- free mounting screen.

5. TESTS

In this section, we have divided into three topics to facilitate understanding; the first comes in a clear planning that we follow for the application of the tests in the field. The second topic – questionnaire – explains the structure of the questionnaires applied; finally, the last topic discusses the implementation itself of tests on students.

5.1. PLANNING

Our evaluation method classifies three groups, according to age group, which makes it possible to analyze the performance of each group modularly. The Group I is composed of students who are ages above 9 years. The Group II has students aged between 5 and 9 years. Finally, the Group III consists of children up to 5 years. Figure 6 presents the classification of groups, along with the distinction between each group.

Test group	Difficulty	Explanation of difficulty*	Age target interval
I	High	7 pieces are joined and with rotation	9 or more
II	Medium	4 pieces are joined and all without rotation	between 5 and 9
III	Low	3 pieces are joined and all without rotation	5 or less

* Tangram has 7 pieces

Figure 6-Table of classification among the groups.

5.2. QUESTIONNAIRE

We worked out a questionnaire as part of our analysis. Each questionnaire was composed of four questions with two alternatives, a correct and not correct. These questions are designed to assess four geometric skills and understanding 3D of the students, who are 1- shadow projection, 2- notion of perspective, 3-projection of faces and hidden edges and 4-volume perception. So, turn each of these skills in a matter illustrated. Figure 7 presents the illustrations used in the questionnaires to evaluate the four skills.

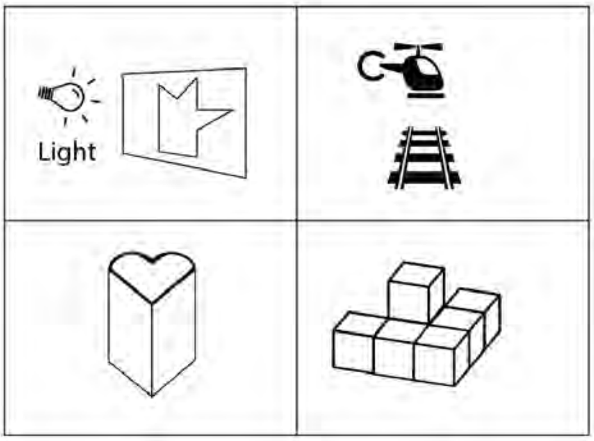

Figure 7-Illustration used for the issues.

The first question uses the image top left of Figure 7, it is about projection of shadows, for this, we ask students to imagine what it would be like a drop shadow behind the punched paper and explained that the lighting was applied to the front of the paper. The second point about perspective, upper right figure, we ask students to imagine what it would be like to see the train tracks by the pilot of the helicopter. In the third issue, which we hope to assess the understanding of the hidden edges, we ask students to select the option that represents the vision behind the pillar, this is the back of the piece. Finally, the bottom-right image in Figure 7, we ask for students scoring option that displays the number of blocks that could exist in the figure, for that, it might in the case of blocks of ice that can fall without support.

5.3. APLICATION

The tests were applied as follows: 1. Application of the analysis tool and 2-Application of the questionnaire. Initially, we ask the children that used the tool to compose the Tangram figure, set to their level. We then apply the evaluative questionnaires and ending with the exercise of abstraction, which consisted of students assemble some figure in freestyle with the Tangram pieces to the analysis tool. During the assessments, reap the duration of the test, the age and the child-mounted model.

We interviewed 31 children aged between 5 and 13 years of age of a primary school in public schools. Data from each group are shown in Figure 8, along with the sample size and the average duration of the exam. Figure 8 shows a table with statistical data, then Figure 9 illustrates the graph outlining the percentage of correct answers between the groups for the four questions answered in the questionnaires.

Test group	Sample size	AVG duration	Question 1	Question 2	Question 3	Question 4
I	15	5:27:16	60.00%	46.67%	66.67%	100.00%
II	12	5:19:25	66.67%	83.33%	58.33%	66.67%
III	4	5:36:30	50.00%	25.00%	25.00%	50.00%

Figure 8- Table of group stats.

From figure 9, we realize that questions 1 and 2, that deal projection of shadows and perspective were better understood in group II, central ages, in contrast, questions 3 and 4, which deal with the notion of hidden faces and volumetric space were better understood gradually, from Group III to the Group I, that is, from younger students understood unless their elders.

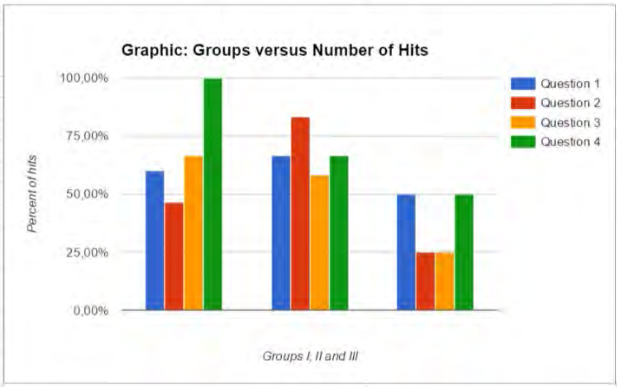

Figure 9-Percentage graph of hits between groups.

6. RESULTS

We observed that children in group III took longer to adjust to the analysis tool and who owned more difficult to imagine the perspective projections-Question 2-and visualization capabilities of the hidden faces-Question 3. We realize that while implementing the testing children in group III used the equipment in the horizontal position, top view, as shown in figure 10. While children in groups I and II were able to interact better with the equipment changing the angle of vision.

Figure 10-Figure obtained during the application running on the child in group III.

We realize that children from all groups in the first contact with the application struggled to handle in the first exercise, which is assembling the parts on the silhouette. In the exercise that the student should freely assemble the Tangram figure, they were already more adapted to handle the application. However, they were as yet felt difficulty understanding the geometry of the parts, synchronize them with silhouettes of models, and needed some aid.

At the end of the tests, we talked with three teachers in charge of classes to evaluate, both have worked with Tangram activities on paper, 2D. The application made by us was very well received by teachers who were very interested in continuing with the material developed by our research.

The insertion of our method to support routine activities of students in class will contribute to further progress and generated returns may be more efficient.

Our review of the figures of low, medium and high difficulties are illustrated in Figure 11. The table of Figure 11 was generated with from our empirical criteria making use of **difficulty explanation** of column constant of Figure 6, Figure mounted to each free the students assessed by those criteria and classify the figure in the levels of difficulty low, medium or high. Note that there is no link between the free figure mounted to the age group I, II or III, of the child, this is exactly what we seek to measure, i.e. the relation between the most complex figures with the group of students, so we can have students in Group I, older, less complicated free figures, or students of the group III setting free more complicated figures, noting that the evaluation criteria between low, medium and high difficulties figures are in Figure 6.

From the models created by students, reap the random sample of fifteen models and put in Table 11. Table 11 was generated based on the classification criteria we use to divide the groups.

Free model made	Difficulty
Tooth	High
Heart	Low
Pinochio sitted	High
AirPlane	Low
Tree	Medium
Doll	High
Bus	High
Hat	Medium
House	Medium
Car	High
Shirt	High
Flower	Medium
Eye	Medium
Truck	Medium
Triangle	High

Figure 11-Table of the relationship between the free model and your complexity.

Figure 12 is a graph generated by the same sample of fifteen students, the horizontal axis represents the percentage of correct answers the student obtained the questionnaires, there are four questions in the questionnaire and the possible percentages are 0%, 25%, 50%, 75% or 100%. In turn, the vertical axis shows the free model assembled by the student.

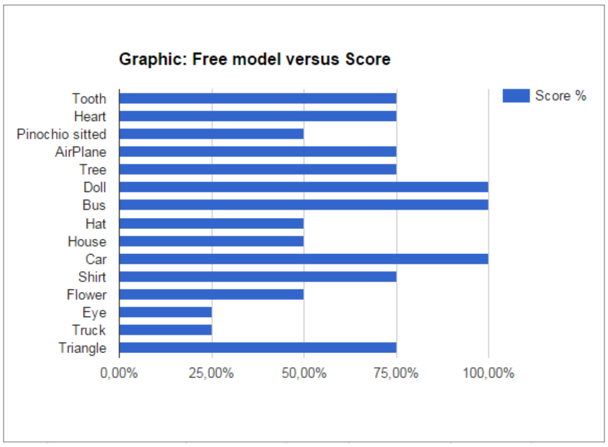

Figure 12-Graph of the relationship between the free model and the score obtained by the student.

The most complex figures assembled by the students were classified as those with high difficulty. Similarly, the figures with the least complex parts are the low difficulty. Based on Figures 11 and 12 we realize that the models with greater complexity were assembled by students who have higher scores in response to the questionnaires.

CONCLUSION

We conclude that the use of the tool to support the class helps in the formation of spatial understanding of the student. Additionally, with the results of the tests, we realized that in fact, the perception of three-dimensional space already reside in each individual, however, the critical view is three-dimensional environments can be worked more efficiently with support tools and activities that explores spatial vision. Thereby, we consider important the contribution of this research in academic and indispensable means to improve the method of capabilities and spatial skills, providing a base for guided each student in its first study classes.

FUTURE WORKS

A range of other studies that can be added in this research, however, shed in the segment of education and spatial vision in the classroom was chosen by us as the main activity subsequent to this study. It would be composed of more parameters vary in order to obtain more representative results. Thus variations would expand the body tests applied on larger samples of children select a larger number of different schools, towards the public and private schools, economically different regions and finally the results of measuring tests is applied in children with mental disabilities, such as people with Down syndrome, dyslexics, autistics, cognitive inhibited, and so on.

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