Geometry teaching, smartphones and QR Codes

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***Abstract* - The evolution of society driven by the digital age has brought significant changes in the school dynamics and, in particular, in the classroom. Mobile phones daily accompany students and are currently computers in small size whose use is generally not allowed in the classroom space and there are even specific legal regulations for this purpose. However, smartphones provide teachers and designers with numerous opportunities to support teaching processes developing innovative teaching and learning contents. In this article we present a didactic experience in the context of the classroom, using *smartphones* and QR codes, which have proven to be powerful in problem solving and in investigative tasks by the motivational factor that triggered the students.**

Keywords: m-learning; QR codes; mobile phones; technologies

I. INTRODUCTION

The subjects around the new technologies have originated continuous publications and are a target of various investigations either by their use or by their potential.

Nevertheless, from this set of technologies beneficial for teaching, the mobile phones have become excluded, for several reasons, despite of the fact that they currently seem to be an indispensable object for the students and hold functionalities close to a small-sized computer. These two characteristics can be availed to stimulate and to motivate students to solve tasks involving specific content on school matter.

However, these equipments, although they may be used within schools, they are not allowed in the majority of the classrooms, having, in fact, specific regulations regarding their use. The diligences adopted by schools to avoid their use in the classroom space find more and more obstacles and have been revealing ineffectives.

So, what if these resources were available to educational programs?

And, what if these resources could benefit by the mobile phones functionalities of the new generation?

In this article, we will introduce a didactic experience with preservice teachers of Basic Education (to childrens with 6 years to 14 years), using, as resources, smartphones or tablets, QR codes readers, the Geogebra program and Tetris, which is a traditional game known by most of these students, and a way to stimulate and to involve them on problem solving and in investigative tasks.

The main goals of these proposals were the development of the competences on the Geometry scope and the understanding of the influence that the resources used had on the students' motivational behavior.

II. THE MOBILE PHONE, THE QR CODES AND THE LEARNING PROCESS

The digital natives, which includes the generation of people born after 1980's, grew up surrounded by the digital technology and are more comfortable with their use than the ones known as the digital immigrants [13]. The smartphones are inserted in this set of technologies due to their set of features that allow them to be recognized as a powerful educational tool for several reasons, among which, always being present amongst students and showing few obstacles to their use [10], [12]. In the world there is three times more telephones that personals computers [3].

In 2009, The Child Forum estimated that, in Portugal, an average of 12% of children aged 4 to 6 years old have already had mobile phones, compared to 55% ages 7 to 10 and 89% aged 11 and 12 years old, respectively.

Accordingly to a study carried out by the author João Carrega, in 2011, using as a case study of 179 students from 9th and 12th grade, 93% of the first ones and 90% of the last ones had a mobile phone with an Internet connection, and the majority of them maintained their mobile phone on during the classes [5].

In 2013 (the last data currently available), PORDATA's Database Portuguese program, showed the existence of nearly 19 million of mobile services' signatures in the country, which is nearly the double of the total of the Portuguese inhabitants. In 2015, these percentages are certainly larger due to the vulgarization of the mobile phone and the social behavioral patterns.

In fact, of all of the accessible resources to children, this electronic devise is the one which occupies the first positions, being used to send text messages, to play, to search online and, in a less scale, to make phone calls.

The frequent text messages exchange between these users provided the appearance of new languages and new concepts of orthography [5]. However, the use of the mobile phone as a didactic resource assumes outlines of something that could be called an Utopia situation. In spite of being assiduous users of these equipments, Carrega's study [5] revealed that neither the students nor the teachers showed an opened mind attitude to embrace it as a learning tool in the classrooms.

Nevertheless, a research investigation developed by the Standford Research Institute [17] pointed out that nearly 90% of the teachers and 66% of the students recognized the advantages of it in the learning process, foreseeing, also, their use in the future.

The mobile phone is assumed to be a counterproductive tool for the learning process [7] because students use it, in the classroom, during classes, to write and to send text messages/emails and to search on Facebook, and its unexpected ringtone could affect their attention [4] and their work' rhythm, and it still can be used for more serious and negative behaviors such as the cyberbullying [9] or to copy [15].

On the other side, the computers and the Internet itself faced a similar resistance at the beginning but, now, they are considered powerful tools on teaching [8].

We should bring up the fact that the number of mobile phones is currently the triple of the number of personal computers [2].

In spite of having already successful experiences about the use of the smartphones as a learning support in the classrooms [6], [18], and studies that suggest its several functionalities that allow the development of competences particular to the 21st Century [14], the mobile phones, on the teaching area, are considered as a more depreciated than appreciated way.

We shouldn't ignore the fact that the learning process occurs when the students are involved on the tasks [2] and, consequently, it is in this view that we want to mainly invest, making use of the programs available on smartphones or tablets beneficial for the Geometry's study, such as, the QR codes.

It is noticed that the mystery that could be behind a QR code connected to the creation of specific tasks might allow the development of competences, even when the students are in different levels of performance [1].

III. Methodology

A. Participants

This study was developed during the school year 2014/2015 in the Geometry subject of the 2nd Grade of Basic Education Bachelor in The School of Education of the Polytechnic Institute of Porto, Portugal (ESEPP). This course lasts for three years and establishes the primary studies for futures educators and teachers of the Basic Education, which is mainly necessary for the admission on a master's degree course that, lastly, qualifies them for the professional practice.

This didactic experience was carried out in three classes, in a total of 5 hours, with groups of two people and together with the presence of the observer.

All pairs had a smartphone, a computer or a tablet, and a QR code reader installed in one of these equipments.

The study' participants, 76 students, were attending this subject in the continuous regime evaluation and voluntarily accepted to make part of our sample.

B. Drawing and Procedure

The experience contained two tasks developed in different moments. The two tasks' main theme was the geometrical transformations that had already been approached in the classes but not in their completely study.

The primordial aim of this investigation was the promotion of an autonomous learning moment with the use of the technology resources.

Task 1: In this task, the students had access to a sequence of clues showed in QR codes that motivated them to the resolution of a police enigma: to discover the house (a square) where it would be an artwork stolen in the place marked in the drawing (see F\igure 1).

All of the squares were houses of a private condominium separated by perpendiculars and parallels streets (outlined).

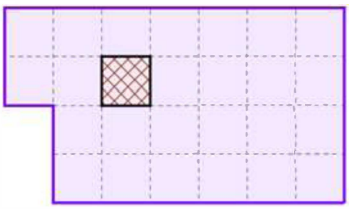

Fig. 1 - Private condominuim plan

In this task, there were involved specific mathematical contents: the study of polygons, the symmetry figures and the nets of an open cubic box.

Besides the smartphones and the QR codes, it was also used the pentominoes and the polydrons whenever the students needed to better visualize it and think about the problem. It wasn't necessary to access to the Internet.

Task 2: The students were primarily invited to play the original Tetris and, then, the TetrisLeb (name invented and derived from Tetris and the Basic Education Bachelor Degree), using Geogebra applets previously built by the the investigators and available in the GeogebraTube.

The difference between the Tetris and the TetrisLeb (see Figure 2) was precisely in the type of isometries susceptible of being applied: in the first, only the rotation and the translation and, in the second, all the four isometries.

The TetrisLeb was formed by a double board whose separator axis allowed applying the reflections.

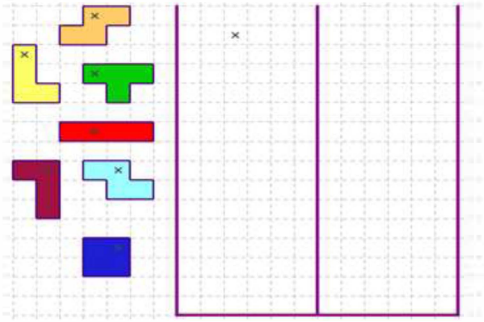

Fig. 2 - The TetrisLeb game in the Geogebra

Two of this tasks' purposes was the problems solving and the investigation of the reflections composition in an autonomous way. Because of that, it was created a landscape formed with several Tetris that could lay down the application of the reflections across the parallels and perpendiculars axis (see Figure 3).

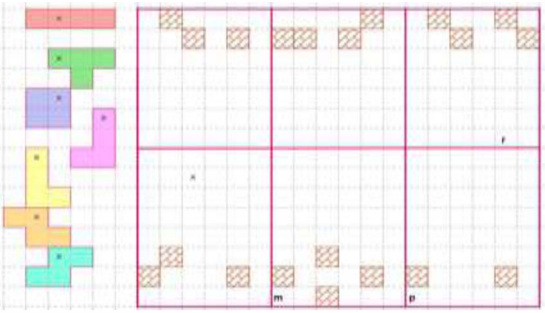

Fig. 3 - The board for the development of the structures of the reflections across the parallel and perpendicular axis

In spite of being understandable to all the students, this task was more complex than the previous one and the proposals showed an increased difficulty level.

In the last proposal, it was intended that the students find a relation between the axis position of the reflection, their distance in the case of the parallel axis or the angle formed through them if the axis intersect and the isometry obtained. In this task, the students were advised to replace the mobile phone for computers or tablets because some mobile phones couldn't allow such efficient and quick use of the Geogebra applets.

The Geogebra app for the smartphones is being developed by his founder's team, Markus Hohenwarter, and, soon, it will be available at Geogebra website (www.geogebra.org).

C. Data gathering

The study data were collected in a comfortable and a well-known environment for the participants, in other words, in a classroom context, being the work pairs formed by them.

The tasks development moments were recorded in an audio and a video file format for subsequent analysis.

The main elements gathered for this study were the answers to the proposed tasks, which sought to gather the maximum information as possible about the reasoning and the justifications presented by the participants. Besides these data, it was also obtained the comments, the questions, the pairs of work dialogues, as well as the observation of the audio and the video records.

IV. RESULTS

In this didactic experience, the students displayed much enthusiasm and the curiosity showed to be a perfect ally in the fulfillment of the main purposes of the tasks.

In task 1, the mobile phone was used to find the solution and, in task 2, the computer or the tablet, mostly (see Figure 4).

Some of the students, even with lesser profitability, preferred using the mobile phone.

Fig. 4 - Resources used in each task

In task 1, the bad options taken by the students in the clues showed had been resulted from the erroneous concept of symmetry understanding, that proceeded, for example, on groups finishing with a different piece from the correct one (see Figure 5) or with more than one (see Figure 6).

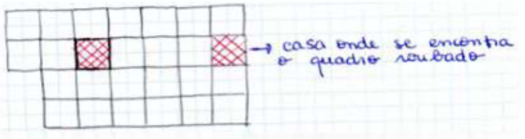

Fig. 5 - The incorrect solution

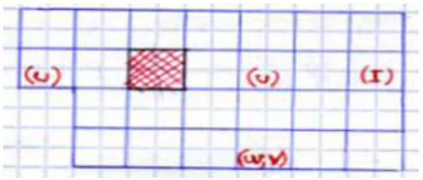

Fig. 6 – More than one solution

In task 2, the contact to the GeogebraTube applets through the QR codes was a major advantage because it allowed a quick and an immediate access to the resource by the simple reading of the QR code.

The work pairs used several QR Codes readers, for example, codeTwo QR code, Quickmark, QRreader.

In this last task, the necessary access to the Internet, because of the applets, was made from the school's wireless network that didn't make any problem.

The students' motivation was even bigger than the previous task, for three main reasons: having Tetris as a reference, which is a game that is memorable for most of the students who liked to play it, the use of the technologies and the Tetris game or the TetrisLeb in the Geogebra's applet mode. This functionality essentially allowed them:

- to reflect about the isometries transformations that were behind of the original Tetris game and in which they had never thought about;
- to investigate autonomously the result of the reflections compositions across parallel and perpendicular axis (see Figure 7);
- to test the movements applied to the pieces (roll, transcribe, reflect) and their compositions;
- to choose vectors, reflection axis, rotation centers and being sensible to the effect of their options in the applied isometry;
- to carry out quickly an idealized movement;
- to remove an easily undesirable transformation after the revealing of their effect.

Fig. 7 - The isometries' use on the Geogebra's applet

In terms of the isometries learning and their compositions, the pieces handling experiences on the applets software were essentials because not all students were in a subject state of mind that could let them to imagine a piece rolling, transcribing or reflecting. Besides that, the students background on a mathematical concepts level involved in the tasks, resultant from the school course that they had in the Basic or in the Secondary Education, couldn't allow them to understand effectively the mathematical demonstrations. So, these experiences followed by a teacher skilled in these matters are crucial so that the conclusions appeared with meaning for these students.

The set of answers given to the task 2 are highlights of the creativity and revealing of the knowledge involved and developed by the students, as we can see in an example in the Figure 8 still in a development phase.

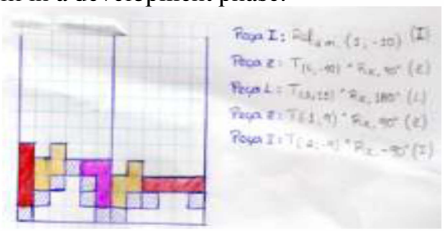

Fig. 8 - A proposal example in development

The amazing potentialities of the Geogebra use, namely on the applets' construction, allowed the investigators to choose the only necessary tools to the task exploitation and thus to reduce the complexity on the search and the consequent application by the students (see Figure 9).

Fig. 9 - Geogebra's toolbar

In the last group of task 2, the study of two reflections' composition, revealed being more complex, especially because some of the Tetris' pieces were symmetrical (I, T and O) and two pairs of the pieces had the same performance when applied to one reflection (S and Z, L and J).

For a next experience, we proposed the use of non-symmetrical pieces to facilitate the conclusions and to reduce erroneous conjectures.

In the end of the task 2, one of the students expressed his profound contentment by the experience developed and added that he liked so much seeing Mathematics in this game that he is going to start to play Tetris game in the Geogebra app.

During the development of this study, the students went through a sequence of stages, without going over them, and there weren't records of the mobile phone or the computer/tablet use to improper ends, due to the level of commitment with the task and a healthy competition between the groups.

Regarding the students' opinions, the records were carried out focusing on three main aspects: (1) Opinion regarding to the task; (2) Opinion regarding to the resources (mobile phone, QR codes readers and pentominoes); (3) The recognition of mathematics use involved in this task.

Furthermore, the groups used several adjectives (for example, interesting, captivating, exalting, dynamic, accessible, fun, creative, and challenging) to classify the tasks made, not having depreciation comments about.

It was also pointed out the fact of being a cooperative task that provided a "healthy competition" environment into the classroom (Rita and Ana).

According to the work pairs about the mobile phones and the QR codes use, they unanimously stated that it was what motivated them the most to the task performance once they had never carried out a didactic experience of this nature.

So, as consequence of the proposal and the resources used, the attention, the dedication, the effort and the concentration were some of the feelings aroused and referred by the students, moved by the curiosity and by the spirit of adventure of a task that were "accessible but that made us think" (Carla's and Vânia's group opinion).

The mathematical contents involved in these tasks were easily recognized by the students, mentioning other besides the predicted ones by the investigators.

In conclusion, to ally this technology to the mathematics learning is a strong idea pointed out by the pairs of work that, in a funny, playful, relaxed and dynamic way, was possible to develop mathematical competences in a significant form.

V. CONCLUSION

The didactic experience showed is integrated in a project rewarded by the Polytechnic Institute of Porto as an Innovative Pedagogic Project in the Distance Learning.

If these proposals were presented in the digital support (PDF), the QR code readers' application would have the same function as a link for the Geogebra applets. Nevertheless, the intention behind this project and its investigators' team is to value the use of paper' resources, in particular, the worksheets and the schoolbooks which are the most used resource in the classroom not only by the teachers [16], for the scientific updating itself, but also by the students for an autonomous study performance [11].

The use of the technological resources presented in the article has also the main goal the experiences that might be used in the Distance Learning, therefore, task 1 focused on a more personalized support by a teacher while task 2 pointed out the autonomous work approach.

The surprise factor and the curiosity of knowing what is behind that QR image was a necessary impulse to stimulate the observation, the manipulation and the visualization that, consequently, motivate the students in learning of the specifics contents approached, in this particular case, in the Geometry matters.

By this time, some may think that this idea won't be accessible to all students, namely those who don't have mobile phones or have smartphones but, at least in Portugal, this conjuncture is practically unobservable in our student community.

We could also be idealizing these situations and imagine the students consulting others functionalities in the mobile phone that aren't contemplated in the task, similarly to what it could happen with classes that have the computers as resource! Certainly that these moments will be carefully prepared and, for example, create mechanisms of responsibility feeling in the students for their own actions, such as the creation of rules by the apprentices like Engel's and Green's activity developed and whose results showed to be very positive [6].

The teachers and the whole remaining school community must look to find integration ways for this technology and to understand that the existence of this technologic bullying [5] will keep on producing reproachable behaviors and increasingly difficult to avoid.

The positive feedback from the groups about the task and the resources presented allowed them to emphasize the motivation for learning, as a main feature, triggered fundamentally by the curiosity on discovering what it was behind each code. It is noticed that the "motivation (predisposition or the wish for learning) must be encouraged through the curiosity, the wish for competence, the will of cooperation and the exploitation of alternatives" (Bruner, 1961, quoted by [13]) thus making QR codes a strong ally to which many times is difficult to realize: the teaching and the learning process.

VI. Future Investigations

The benefit for the Geometry's teaching and learning process with resource to dynamics environments, the importance of the visualization for the development of the geometric thought, or our students' difficulties, and even from the professionals, in this area of the Mathematics, are object of the most several specialty studies.

The technological resources are tools that may facilitate the Geometry's learning process, even more when these resources include smartphones, considered today as routine for our students.

In this regard, it would be really interesting to develop similar didactic experiences, like the described one in this study, using the new application program for smartphones soon to be available, according to information on the Geogebra website.

Thus, we might understand better the relation between the students and the mobile phones when these are used as a support to their own learning process.

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