An Open Problem in the Use of Software for Educational Purposes

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Abstract: In this paper, we describe a pilot study concerning the calculation and the comparison of areas of complex shapes through problem-solving tasks with the support of technology. The tasks were presented to primary school students. Emphasis is given to the fact that an incompatibility exists sometimes between what the teacher wants to do and what the software provides, based on their possibilities. A usual practice that has also been applied here is the necessity for a combination of software applications in order to face one problem. But even this can not eliminate all difficulties. Thus, we contend that when we want to use multiple software applications for area determination, “one is not enough”.

Introduction

It is commonplace that the use of ICT (Information and Communication Technology) in teaching is constantly expanding and transforms the way subjects are taught and influences even current curricula. The ICT offers today the possibility of creation and instructive use of learning environments with particularly cognitive characteristics and create thus a very favourable frame for teaching and learning. Modern educational software is characterized by an abundance of different types. There exist simultaneously drill and practice environments, tutorials, multimedia applications and generally a lot of types of educational software. They continuously offer more possibilities to the user. Trying to use educational software for the teaching of elementary geometry concepts like area and its measurement, we realized progressively that at least in such elementary level, one is not enough. That is to say, no software is enough for the teaching of elementary mathematic concepts. Further investigation showed that this does not constitute a unique or rare phenomenon. On the contrary, it is in effect in most cases. This is not only due to weakness in the designing of modern educational software but also to the completely idiosyncratic character of teaching. In the present work we concisely present the designing of teaching of areas and the didactical needs that led us progressively to the adoption of many educational environments, instead of one, and simultaneously we try to generalize conclusions.

Contribution of Technology in Geometry Problem-Solving

A lot of research has dealt with the positive effects of the ICT in the process of teaching and learning. Especially for the contribution of technology in geometry problem-solving the following could be stated:

• The use of computer as tool of verification, confirmation, to control conjectures and conclusions.
• The direct comparison and relation between what the student thinks and waits for as expected result and what sees in his/her screen so he/she can immediately react to them (Balacheff & Kaput, 1997).
• The possibility of multiple solutions. At the same time we can have a variety of solutions for the same problem (Lunts, 2003).
• The student can work independently from the teacher. He/she can produce copies of shapes, place them where and as he/she wants, decreasing thus the possibility of misunderstandings.
• The concept of measurement acquires substance and content (e.g. the virtual use of simple units of measurement of area or complex units, that is bigger units that are constituted of smaller ones), a parameter particularly important in problem-solving (Reynolds, 1996).

The Case of Software: One is not enough

Despite the positive effect concerning the contribution of technology to geometry problem-solving, a more careful study of the results of relevant researches makes obvious a reservation that appears to exist in the research community with regard to the suitable choice of software as much as with the question if finally “one is enough”. Initially it should be clear that it is a challenge for the teacher to provide to students the suitable software for each case, in order to help them to cope with the task they face (Gawlick, 2002). The most appropriate choice for either one or the other situation depends on the use the software is geared for. For example, the study of space from a geometric perspective might demand its simulation, in order for the learner to be able to relate and solve geometric problems under “real” conditions (Dagdilelis, 2004). Many times, the students utilize effectively a variety of different software in order to achieve the solution of one and only problem (Dugdale, 1999). This strengthens the opinion that the “monism” presents a difficulty with regard to the applications or more precisely with regard to the effort to solve mathematical problems based only on one computational application (Schummann, 1997). This difficulty lies in the fact that no one of the already existing computational applications, gives to the users complete control of learning. All of them satisfy partly the concept of control of learning from the user incorporating simultaneously the control from the program itself (Lunts, 2003). It could not be differently since behind each software exists the person who designed it and that he did not have in mind the particular student or the particular situation in which the teacher decides to use it (Bender, 1999). Finally one is not enough.

Description of the Pilot Study

The Pilot Study was accomplished by students of the 5th grade of a primary school in an urban area of Greece. The topic was the calculation and the comparison of areas of complex shapes. When we say “complex shapes” we mean the ones that can be divided in other simpler and known to the children shapes (triangles, squares etc) that are recombined to create a new shape of equal area but of different form. The tasks we selected were non – standard. They required comparison of areas (Activ.1A and 1B), estimation of areas (Activ.3 A, 3B and 4) or estimation of the whole area but also parts of it (Activ. 2) (Fig. 1). More specifically activity 2 shows the form of the courtyard of the school and the children are called to separate it so the ½ of it becomes football region, 1/4 volley region, 1/8 to play “apples” (a traditional Greek game) and 2 regions equal with to the 1/16 of courtyard for “skipping rope”. We used three different applications (Cabri. GeoComputer, MSPaint). Depending on the task the students had to cope with, either they used only one of the software, or a combination of them. We used also the Camtasia Studio applications in order to record the activities of students in the computer screen so as to see later the effort of each student and to locate and analyze errors and
strategies. Finally we used a video recorder to record the two populations working in their environment and a tape-recorder for the interviews taken after the completion of children’s work.

Software Contribution to the Desired Use of Computer

This didactic choice meant also a corresponding organization of instructive material: for example we should allocate instructive tools to allow the potential covering of not regular surfaces with units of variable and regular size but no unique shape (for example squares and triangles). The use of computer in problem-solving activities as the above ones provided us with a series of parameters, which are important for the confrontation of such activities. Simultaneously it strengthened our basic idea that "one is not enough". Through the use of software we realized the different ways students use the computer:

A. Use of computer as a means of safe and reliable counting. It is known that in paper-pencil environment activities, exists the problem of safe enumeration. The correct enumeration is this one which I count all, without omitting no one, measuring however once each one. The computer in activities 1A, 1B, 2, 3A and 3B was used as a means that would allow this safe counting. The children in order to calculate the area in the above activities applied two strategies. Some of them created a square grid and then began to paint the whole square units so as to count them correctly. Others defined a square unit area and then with continuous “paste” of it (tessellation) they tried to cover the under study shapes, counting the number of “paste”, that would give them the final area.

B. Use of computer as a means for the normalization and incorporation of the shape in a recognizable frame. It appeared that the students whenever came across an unfamiliar shape, they incorporated it in a recognizable frame. In activities 1A, 1B, and 2 in the initial screen existed only the geoboard but not the grid. The creation of the grid was the first choice for most children in the laboratory. This incorporation of the shape in a grid (recognizable frame) allowed the students to do more easily the asked calculations.

C. Use of computer as a means of safe and easy management of shapes (transformations). Since the students had to compare areas or to realize whether what appears to the eye equal or unequal, is really such, they resorted to the possibility the computer gave them. That is of transferring, of rotating, of superimposing pieces, without necessarily keeping in mind all the moving and removing of the various pieces they did. In activities 1 and the 3A, B students "placed" square units in order to cover the shapes. They managed safely the concept of area since now they avoided the coverings between units and the existence of gaps between them. Some of them subdivided the square units in two equal triangles. Others placed the pieces they had to compare in the remaining part of the computer screen. They even put them with the same orientation in order to realize whether the shapes have the same area (Fig. 2).

D. Use of computer as calculator. The numerical operations are the object of learning in the first classes of the primary school. This action later becomes a means in order other concepts to be acquired (“double life” of concepts). In problem-solving, the students arrive to the correct result when they not only conceive the right way of solution but also accomplish precisely the numerical operations without wasting valuable time. In the case of Cabri students used the tool "Calculate" in order to apply the formula for the estimation of area and to execute the required operations quickly, easily and correctly.

E. Use of computer as a means of verification Many of the students were not satisfied when they arrived at a solution. It appeared that for them it was important to be sure that this solution was the correct one. Thus in activities 1 A, 1 B, 2 and 4 after they had calculated the asked area, they also used the tool "Area" of automatic calculation (in the GeoComputer as also in the Cabri) in order to realize whether their solution was correct. If it was such they would stop. Otherwise they would keep on trying.
F. Use of computer as a means of reduction of teaching noise. The term teaching noise refers to the undesirable side effects such as extremely long calculations, which can totally overshadow the real objective of the lesson (Cypher, 1994). As we mentioned above the concepts we face in teaching process have a "double life" for students. In our case, in the first courses in the beginning of the school year, the children dealt with the concept of height as object (e.g. what is height, how we draw it, how we measure it etc). Later in the thematic unit of area the height is not anymore the aim but becomes the means in order to calculate the area of a certain shape as the triangle or the parallelogram. Even as a means however, the height causes undesirable teaching noise. For example the students consume valuable time to draw correctly the height or measure it precisely. Thus in activity 4 the computer is used for the reduction of teaching noise rendering the object as a means, with the use of the tool "Distance or Length" and "Perpendicular line" in the Cabri. Errors are avoided in the drawing of height, which is quickly realized. Time is gained in the calculation of complicated operations and so on.

G. Use of computer as a means of reduction of complexity. It specifically concerns the activities 3 A-B. We are talking about the process of analysing of a complex shape to simpler pieces that are recombined to create a new shape of equal area but of different form through the actions of "cut", "paste", "rotate" etc (Batroo, 2002; Battista, 1998). The possibility to make the transformation mentally without the support of the computer for the 3 B appeared prohibitory because during their effort the children lost the control (which piece is transferred and where). The use of computer gave the following advantage: The students could visualize each choice of removing or even undo wrong choices through the possibilities of copy, paste, rotate, different colouring etc (Figure 2). In this phase it is important that we gain all the "intermediary situations" of the transformation until the student reaches the final shape starting from the initial. We collect thus a lot of information about every student’s strategy, which could be lost in the traditional environment of paper-pencil (Owens & Clements, 1998).

H. Use of computer as a means of recordability. (that is, the ability to continuously record the user's actions). Recording the activities of each student we had the possibility to be adapted to his/her needs and to provide teaching help. When we studied and analyzed these activities, we gained important information concerning the strategies the children had used and the serious mistakes they had made. Then the whole class had the possibility to watch, locate and comment on these strategies and errors.

Two parameters were also included in the planning of the pilot-study that did not appear clearly in the above description.

Personal interventions in the software: In several cases the shapes were not convenient for an easy measurement using only the square unit. In order to facilitate the estimation of area of those parts of the shapes that were smaller than a whole square unit, we created a series of additives square units that were divided in 2, 4, 10 equal pieces. In activities also that required combination of grid and transformation it was impossible to complete the task based on just one software. Cabri gave the grid but it couldn’t remove parts of the shape, something that could be done by MSPaint. Thus in this case we tried a combination of the two software, so both activities coexist in the same screen.

Restrictions in the software’s capabilities made desirable uses of the computer unattained. Such uses were: a grid that could easily change the shape of its units, enlargement of certain regions to facilitate
subdivisions, and a tool of automatic measurement of whole square units that exist in a not regular shape. Thus students would have more time to deal with the part of the shape that presents bigger difficulty and to which the square unit subdivisions should be adapted.

**Reservations Instead of Conclusions**

In a non-technological problem-solving environment we would give emphasis in the student as “capable problem-solver”. This presupposes two parameters. From the one hand the existence of a repository of tools at the student’s disposal: calculator, ruler, compass, computer etc. From the other hand the student must be able to recognize whether a computer solution provides advantage and to select from the software-repository those tools that better apply to his/her case (Dugdale, 1999). The choice will be his/hers. The usage will not be guided. The teacher will simply show him/her the capabilities the tool provides. The question which computer application helps better to the solution of a specific problem, is not related only to the student, but mainly to the necessity of capable and updated teachers and software designers (Schumann, 1997). This necessity in combination with the fact that “one is not enough” leads to the formulation of a double open question that faces a teacher when his/her students are involved with the concept of area and he/she wants to integrate technology as helping tool:

1. Should we be directed towards a software that would incorporate all the already existing (and necessary) software to utilize their various capabilities? What about the great cost of learning so many software?
2. Should we be directed towards a new software, based on the above-mentioned criteria, that would satisfy sufficiently all our needs in order to cover the thematic unit of area?

A prospect of the first type appears to emerge with the creation of modularized software, constituted from collaborating components that can be composed accordingly with the didactical needs of each circumstance. However, even in this case, the relative experience shows that the complexity of software like this is too big (e.g. the e-slate software) and at the same time a non-trivial know-how is required from the teacher. Up till now the use of multiple software for the teaching appears to be often owed so much to a lack of relative maturity from the side of designing of educational software, as to the singular character the didactical situations present. This problem appears to remain open.

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