PAPER TEMPLATE

GEOGEBRATAO, VALIDATION OF AN ADAPTIVE LEARNING ENVIRONMENT OF DYNAMIC GEOMETRY. SOURCE OF A DIFFERENTIATION INDIVIDUAL PATHWAY OF THE STUDENT?

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In this PhD project, about 250 Luxembourgish children of 10-12 years explore elementary geometric concepts in a sequence of learning activities, created with the dynamic mathematics system GeoGebra integrated into the computer-assisted testing framework TAO. The children, who are active in their learning process, are allowed to build new knowledge in an autonomous way and at their own pace. By means of a snapshot of the stimulus containing useful, easily exploitable data, the computer, a diagnostic tool of the competencies of the children in geometry, interprets the answer offered by the child, and based on this answer, gives relaunch instruction to go off to further explore the concepts. So children with special needs are identified and a differentiation individual pathway is inferred through scaffolding or feedback practices. Comparing the obtained results of a pretest and a posttest will allow us to assess the gained knowledge of the children.

INTRODUCTION

In this paper, we present the project « GeoGebraTAO, validation of an Adaptive Learning Environment of dynamic geometry. Source of a differentiation individual pathway of the student? », a current PhD thesis at the University of Luxembourg. First of all, we explain, how this study is founded by theory and how it originates from practice, then we illustrate the central pedagogical research goals, after this we present the user interface design of our software and its fundamentals, and last but not least we speak about the research design we use in this study.

Development of the project

We have been involved in the project GeoGebraPrim (Kreis, Dording, & Keller, 2010), which started in January 2007, related to the dynamic mathematics system GeoGebra that investigated the advantages of the usage of such software in primary grades, as well as its integration into the computer-assisted testing framework TAO (Latour & Martin, 2007). The aims of this project were on one hand the improvement of the children's understanding of the elementary geometric concepts and on the other side a deeper insight in the bond of geometry and algebra. This prior research achieved already at the University of Luxembourg can be considered as a promising springboard for thoroughly analyzing computer-assisted learning activities in primary education.

Furthermore, on the one hand, we want the children to learn, to build on prior knowledge, and on the other hand, we don't want to communicate knowledge « directly », that means without letting the children construct the concepts for themselves [Brousseau] (Falcade, 2006). According to Judy Olson and Jennifer Platt (2000), the teacher (our software) must provide assisted activities (in our case computer-assisted activities) that are just one level beyond that of what the child can do. Relied on GeoGebraPrim (Kreis et al., 2010), in this study, the children build the concepts via sequencing learning dynamic activities themselves, without the help of their teacher, but through scaffolding and clear feedback practices given by the computer, like provided relaunch instruction that is adapted to each child's ability. One well known approach to facilitating learning, especially the acquisition of and reasoning with abstract concepts, is through scaffolding (Wood, Bruner, & Ross, 1976), in which various kinds of learning materials are used to help the child … that initially lie beyond their ability (Masterman & Rogers, 2002). During our project, the child is assisted through the zone of proximal development, that is the gap between what a child has already mastered (tested in a pretest) and what it can achieve when working with our software (Coffey, 2009).

Besides we have experience as teacher in different classes and we are well aware that such a software could be very useful in addressing the difficulties a teacher may encounter in its transmitting task of knowledge, in particular in helping the teacher to reach the wide range of ability levels in the classroom, while ensuring all children are challenged and mastering required content.

Central pedagogical research goals

As described before, the children build new concepts via sequencing learning dynamic activities themselves through successive levels of temporary support (scaffolding, relaunch instruction, feedback, possibility of getting help). Since their knowledge is unevenly shared in the different schools and classes, this teaching approach allows each child to use our educational software at its own pace. A stronger child gets less relaunch instruction, thus goes faster through the activities, and further in the anticipation stage so that its knowledge can be reinvested. From time to time, it gets additional computer-assisted learning activities to ensure it feels appropriately challenged (not bored) in its school environment. A child, who struggles to understand a concept, gets repeat instruction and support, and repetitive activities until it is ready to progressively be moved toward stronger understanding; it should not feel overwhelmed when working with our software.

So, by interpreting the answer given by the child, the computer balances expectations and thereon provides individualized support by incrementally improving a child's ability to build on prior knowledge and to internalize new mathematical concepts (Coffey, 2009). Using scaffold instruction is, according to D. Wood, J. Bruner and G. Ross (1976), a process that enables a child … to solve a problem, carry out a task or achieve a goal, which would be beyond his/her unassisted efforts.

In building this software, we must be aware of the task a child is able to carry out, we must know the next step in the gradual release and how the computer has to intervene if a child needs help. The activities have to be simplified, through successive levels of temporary support, to be achievable for each child. The support must consist of clear feedback and instruction on progress, and the children's confusion must be reduced to maximize learning potential.

Furthermore, more responsibility is transferred to the child so that it gains mastery over the computer-assisted learning activities and can use the software independently when no adult is present. By the way, it is claimed that interactive software can provide a kind of mental scaffolding. At the lowest level, it can provide the incentive to continue to work on-task for longer periods without the intervention of a teacher (Somekh, 1996).

User interface design and layout of our software

The child's motivation may suffer if the interface is too complex. And so we have chosen a simple interface and we try to be consistent in the layout of its easily accessible and understandable elements. We use a layout with just a couple of elementary colors.

Figure 1: Example of a computer-assisted learning activity

Basically, the activities are split into two main columns. The title bar of the respective activity is situated above these two columns. In the title bar, you can find the French flag onto which the children can switch to French text once the mouse pointer is over it.

The upper half of the left column is the block where mainly the teaching objective, the directions and the instructions are clearly stated. By using the principle 'less is more', we tried to keep the text of this block brief and simple, not to overload the children by reading it. According to Barbara L. McCombs (from the mid-continent Regional Educational Laboratory, McREL), providing clear objectives and instructions is one of the features for any activity to be motivating (Viau, 1997). Through the sequence of learning activities, the children learn to follow these directions, which is a skill that proves useful in many areas. Furthermore, in some activities, true/false questions, multiple-choice questions and fill-in-the gaps sentences, in relation to the respective movements in the GeoGebra applet, are situated in this area. At the lower half of the left column, the child can get help. In the activity of figure 1, the help is built up of a video clip explaining how to localize a point in a coordinate system. For the video clips, we use a screen capture software that records a GeoGebra applet and a mouse pointer and keyboard action visualization software. So we do not need to add sound, as most of the schools don't have enough headphones. The children can see what they have to do with the mouse. A visual help may reinforce the learning process of GeoGebra. The help may also consist of a picture explaining a specific concept.

The GeoGebra applet is situated at the upper half of the right column. This ease-of-use dynamic worksheet allows children to work on the given instruction by modifying a dynamic figure (Hohenwarter, Preiner, & Taeil, 2007). For example, there exists an activity in which the worksheet allows children to determine the symmetry axis of a square by interactively modifying a dynamic figure. From time to time, some visual scaffolds are given by the GeoGebra applet. The white box, at the bottom of the right column, forms the feedback box, the scaffolding box and the statement of purpose box. It is very small, so that the text has to be short but effective. Next to this is the next activity button.

Research design

We use a pretest-posttest design; about 250 Luxembourgish children of 10-12 years are studied before doing sequencing learning activities and after the experimental manipulation. There is only one group of children and all of them are in the same experimental condition. They all use the same software at their own pace in a classroom, during about 15 hours, as far as possible without the help of their teacher. The posttest is not exact the same as the pretest, because of a practice effect; the children could have remembered some answers and we want to assess their gained knowledge.

Besides this pre- and posttest, we collect data through TAO (Kreis, Dording, Porro, & Jadoul, 2010) that gives us the means to quickly assess the child's progress. Amongst other things this data allows reconstructing the movement of the points and lines the child manipulated, maybe in order to think and to reason. So, we can analyze the exact individual pathways. TAO smoothly supports this powerful pedagogical tool.

Conclusion

We hope that, through this project, teachers can be supported in classes, by offering sequencing learning activities using scaffolding or feedback practices via computer to their gradually independently working pupils. Relieved teachers can devote more time and attention to each child, what will probably have positive effects on each child's engagement and help him/her to improve.

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