Mathematics Teachers as Multimedia Lessons Designers

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This paper describes two studies undertaken in Serbia and Finland concerning learning through multimedia design, through which (future) mathematics teachers developed HTML files comprising Java applets downloaded from the Internet. The paper also reports some findings of these studies, focusing on what could and what could not be easily achieved through this project. Some research findings regarding further research on multimedia teaching/learning are included.

Introduction

Multimedia, which refers to a computer system based upon the integration of various media such as text, sound, graphics, animation and video, is a powerful tool for knowledge construction (see Jonassen 2000). As those, who learn more from the instructional materials, are their developers, not users, (future) mathematics teachers should design multimedia lessons and thus become knowledge constructors rather than knowledge users.

Multimedia lessons should be developed on sound *multimedia learning principles* (Mayer 2001). These principles are of course subject dependent, and in the case of mathematics may require the following: (1) develop multimedia lessons by at least combining words and pictures; (2) achieve a solid technical realization; (3) show the underlying mathematical structure of the chosen topic; (4) present its application(s); (5) enable various learning paths within it; and (6) deal with relevant procedural and conceptual mathematical knowledge and the links between the two. While principles (1) and (2) are self-explanatory and probably required by any multimedia design manager, principles (3) – (6) are derived from Kadijevich (1988)[1], Haapasalo & Kadijevich (2000) and Kadijevich (2003).

When time is limited, our strategy concerning the implementational issues of multimedia lessons development may primarily be procedural or conceptual (cf. educational vs. developmental approach in Haapasalo & Kadijevich 2000 or 2003).

- The *procedural approach* involves a harmless playing with a prototype of a very simplified applet site on the host computer after which the following question is asked: “What about changing the text and the interactive picture to achieve something more mathematical for pupils.” To make the necessary changes, students need quidance about what parts of the document they can develop. At the starting point, it is enough to learn to reveal the HTML code. After learning to open simultaneously a page on the host computer and the desired applet page on the Web, students can recognize the similarity in the critical places. Hereafter, they learn quite easily to make changes with trial and error, for example. This approach may suit a tutor who has just a little of expertise concerning Java

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[1] This paper also underlines the historical and epistemological issues of mathematical knowledge. To make the design process easier for the students, these issues were not listed among the design requirements.

applets or HTML codes. However, problems can be encountered when the students loose the logic of their actions.

- The *conceptual approach* is based on a mini-lesson about knowledge of a Web page involving an applet, i.e. what minimum requirements would be necessary and what is the logic of the HTML source structure. Furthermore, students are hoped to understand the advantages and restrictions of particular programs to create, edit and browse HTML pages that contain applets.

These six principles and two approaches were used in two studies involving Serbian and Finnish (future) teachers of mathematics. While the Serbian study focused on the principles, the Finish one examined the two approaches. We describe here these studies and summarize their main outcomes concerning what could and what could not be easily achieved through the applied projects. We also include some research findings concerning further research on multimedia teaching/learning.

Description and outcome of the Serbian study

Description

As a part of the course Didactics of Computer Science - taught at Mathematical Faculty, Belgrade University – future secondary teachers of mathematics and computer science (a two-subject study group) developed multimedia mathematical lessons. At the beginning of the project the teacher (the first author) explained the above-mentioned design principles to the students and listed some Web sites where suitable, applet-based lessons can be found.[2] He also suggested to use dynamic geometry software, the various demo versions of which are freely downloadable from the Internet.[3]

The multimedia designers worked in 12 groups (mostly two students in a group), elaborating topics chosen by themselves. The project lasted five weeks and *no technical support* was given to the students. The teacher only suggested some improvements of the lessons (one or two revisions) to those students who sent their solutions via e-mail asking for a feedback.

Outcome

The twelve groups developed multimedia HTML pages on the following topic: squaring a binomial; doubling a square; triangle medians and the centroid; circle and angles; the golden section; similarity; pyramid; the low of sine; ellipse; hyperbola; derivative; and integral. Although various technical solutions were applied, most students based their lessons on Java applets, which were taken from the Internet and/or especially developed for this multimedia project. Apart from combining written words, pictures and applets, some students (six developed artifacts) included various animations (e.g. applets, Flash objects, etc.).

Each developed artifact was presented by their authors within 10-15 minutes in front of the class (a beamer was used). These presentations revealed that the designers developed multimedia lessons at a good technical level despite the fact that many of them initially lacked technical skills relevant to their pursued approach (using Java applets within Web pages; the work with Front Page, Flash, Java, Euklid and other utilized programs).

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[2] For example, www.gomath.com, http://www.ies.co.jp/math/java/, and http://www.saab.org/moe/start.html. At the beginning of the reported studies both of the authors explicitely told to the students that, because of possible copyrights, material downloaded from the Internet could not be used for commercial purposes.

[3] See http://www.mathsnet.net/software.html, for example.

As regards the above listed multimedia project requirements (3)-(6), (3) and (4) were much easier than (5) that was much easier than (6). Requirements (3) and (4) ─ dealing with the underlying structure and applications of the chosen topic ─ were more or less implemented in 11 developed artifacts. Some kinds of different learning paths were implemented in 8 artifacts (intuitive and theoretical approaches, two solutions of a task, two ways of introducing a concept). Only 2 artifacts tried to respect the P/C requirement (determining a position using the concept of hyperbola, procedural/conceptual quiz questions). However, having in mind the subjects' experience and relevant prior knowledge as well as the subtlety of the proceduralo-conceptual issues (cf. Haapasalo & Kadijevich 2000, 2003), the project can be considered successful (see Kadijevich 2002). Four screenshots concerning one of the best develop artifacts are presented in Figures 1 and 2.

Figure 1. Multimedia ellipse: home page and interactive quiz page

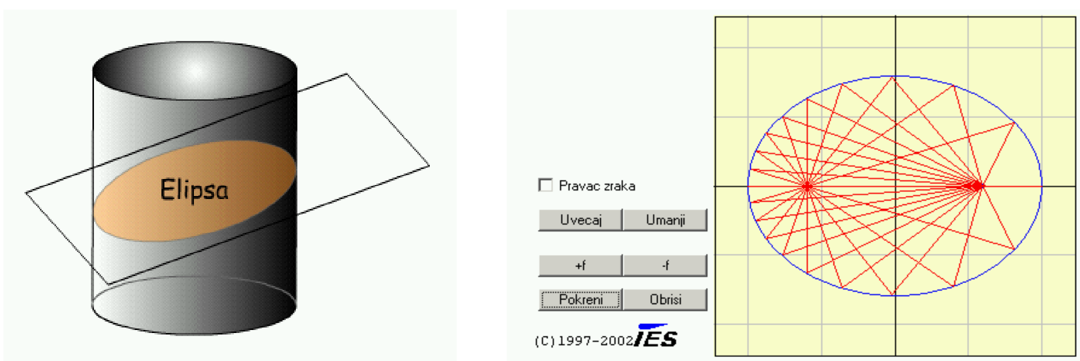

Figure 2. Multimedia ellipse: examples of animations

Description and outcome of the Finnish study

Description

For 22 students in teacher education at the Pedagogical Faculty of the University of Joensuu (http://www.joensuu.fi/), the second author organized an intensive workshop following the guidelines applied in Belgrade. Because of technical problems in the schedule, the guided workshop was restricted to 2-3 hours only. Instead of giving students the task to prepare their own works within a couple of weeks and then represent them as in Belgrade, very open-ended goal was introduced. This resulted in end products that mainly focused on technical aspects (not pedagogical or multimedia). On the other hand, this kind of goal setting gave students opportunity to consider how to integrate multimedia production in their normal studies. Furthermore, the workshop was aimed to give experiences how introduction to this kind of multimedia could be done in an optimal way when time is limited. For this purpose, the above-mentioned conceptual and procedural approaches were used in an "exaggerated" way. While the former was applied for the secondary mathematics teachers, the latter was used for the primary teachers.

Outcome

From the first beginning, it was quite clear that the order of the applet sites in the given guidelines paper influenced the choice of the topics. The secondary mathematics teachers (N=12) mainly visited SAAB sites and picked up applets concerning functions or graphs (ca. 50 %), trigonometry (ca. 30 %), Pythagorean theorem, Fourier series, Lorenz transformations, or physics[4]. Most of the primary teachers (N=10) chose place value system[3].

Concerning the impact of the pedagogical polarization, the procedural approach caused more pedagogical discussions among the students. They considered what would be interesting for children more than technical issues of their Web pages. On the other hand, the conceptual approach forced students to discuss the logical and technical structure of their Web pages. Students just picked up an applet and started to test how the method works technically. After about one hour of working students could proceed without using the guidelines or the instructor's help as much as the procedural group did.

Because of time limitation, most students reached only multimedia design requirements (1) and (4). However, many students (especially within the conceptual approach) discussed improvements they could do to their productions if they would have time to do that. Thus, also requirements (2) and (3) were implicitly involved. The open-ended goal setting of the workshop caused an ambitious end by a group of secondary mathematics students, who started to design their own applets aiming at a sophisticated material for teaching and research purposes, which is based upon all six multimedia design requirements (see Figure 3).

Students were quite satisfied with their success, and their own requirements were quite compatible with the end products. (Some students in the procedural group did not like the feeling that they just proceeded without knowing why particular actions worked and why some did not.) Most students expressed encouraging comments about pedagogical ideas gained through the workshop. (The only negative opinions were directed towards some technical difficulties with software, e.g., generating HTML code by using MS word). The students' differences in computer experience did not cause any problems as the students themselves defined the goals for their products.

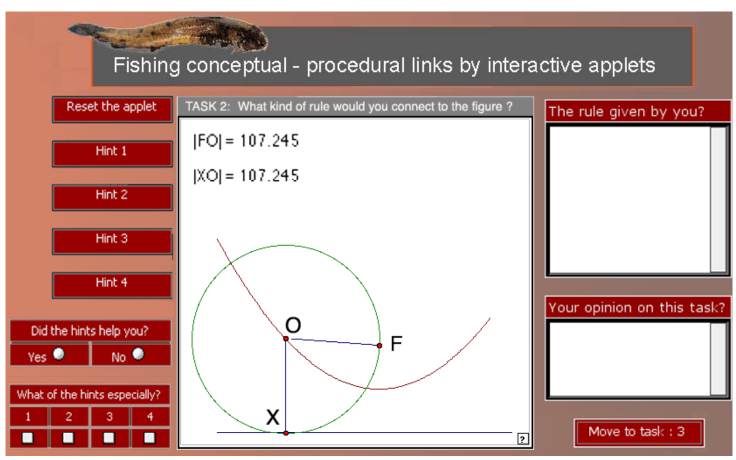

Figure 3. Multimedia conics: researching links between conceptual and procedural mathematical knowledge (see http:/www.joensuu.fi/lenni/SA/conics.html)

[4] See http://www.saab.org/moe/start.html and http://www.tux.org/~bagleyd/java/AbacusAppJS.html.

Closing remarks

When designing any learning environment, we always meet a certain conflict between conceptual and procedural knowledge: Should the learner understand for being able to do, or vice versa? (see Haapasalo 2003). Implementing of technology makes this more complicated, but still provides significant opportunities for alternative teaching/learning paths, especially when learning through design is utilized. It is our task to uncover and explore these paths contributing to a better mathematics education for both students and their teachers. It is true that teachers may have difficulties in accepting flexibility in the multimedia based learning of mathematics (cf. Forcheri *et al.* 2001), but there is an evidence that a multimedia-centered instructional design can improve educational practice, provided that pedagogy is linked to technology, instructional units are planned collaboratively, and a support in their classroom utilization is given to teachers (Cleland *et al*. 1999). Having in mind this study, such multimedia design projects should also be used in the professional development of mathematics teachers. To benefit from them fully, we have to realize their main critical issues and handle them in an adequate way.

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