FOUR CRITICAL ISSUES OF APPLYING EDUCATIONAL TECHNOLOGY STANDARDS TO PROFESSIONAL DEVELOPMENT OF MATHEMATICS TEACHERS

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ABSTRACT

To have students adequately prepared for adult citizenship, computer-based technology is to be routinely used at schools and universities. To achieve this end, new approaches to teacher education are to be developed and utilized, which should be based on some suitable educational technology (ET) standards. As computers are, in general, rarely used in mathematics classrooms, such an ET-based approach, enabling these standards to be eventually widely applied, requires several issues to be kept in mind and dealt with in an adequate way. The most important among these issues are probably the following four dealing with basic indicators of ET standards, computer attitudes, software selection and a proper utilization direction, and Web-based professional development of mathematics teachers. This paper examines these four issues, offering practical solutions that may be used in the design and utilization of an ET-based professional development for mathematics teachers.

Introduction

To have students adequately prepared for adult citizenship, computer-based technology is to be routinely used at schools and universities (Pelton & Pelton, 1998). To achieve this end, new approaches to teacher education are to be developed and utilized, which should be based on some suitable educational technology standards, like those developed by *International Society for Technology in Education* (http://cnets.iste.org).

The current edition of the ISTE National Educational Technology Standards for Teachers comprises 23 indicators divided into six broad categories. They are: technology operations and concepts (2); planning and designing learning environments and experiences (5); teaching, learning, and curriculum (4); assessment and evaluation (3); productivity and professional practice (4); and social, ethical, legal, and human issues (5). These standards are connected with the ISTE Technology Foundation Standards for Students comprising 14 indicators, which are organised into the following six categories: basic operations and concepts (2); social, ethical, and human issues (3); technology productivity tools (2); technology communications tools (2); technology research tools (3); and technology problem-solving and decision-making tools (2).

Computers are, in general, rarely used in mathematics classrooms (see, for example, Manoucherhri, 1999). To have these standards eventually widely applied in mathematics education, an ET-based approach to professional development of mathematics teachers may primarily require us to keep in mind and adequately deal with the following four issues.

1. Many teachers, especially those less-experienced and not so technology-minded, may find 37 indicators of the ISTE standards quite demanding. A solution may be to base teaching practice just upon several basic indicators, still bearing in mind the broader context. What, then, may such indicators be?
2. It has been realized that computer attitudes influence not only the acceptance of computers, but also their use as professional tools or teaching/learning aids. To have computers widely used in mathematics classrooms, we should help teachers develop positive attitudes toward computers. What may a promising way to achieve this be?
3. What is the most appropriate software for the teaching/learning of mathematics? Secondary teachers may primarily base their classroom activities on a computer algebra system and a dynamic geometry environment. What should a proper utilization direction of these or other able programs be?
4. Being aware of rapid developments in educational technology, how to achieve and maintain a critical, balanced and well-designed use of computers in mathematics education? Is Web-based professional development of mathematics teachers an adequate solution? What can be achieved by its use?

The next section deals with these four issues in more detail, providing concrete answers that may be used in the design and utilization of an ET-based professional development of mathematics teachers.

Four Issues

Basic indicators of ET standards

As a part of the course *Didactics of Computer Science*, which the author has taught at the Mathematical Faculty of the Belgrade University (http://www.matf.bg.ac.yu) since the academic

2000/2001 year, future secondary school teachers of mathematics and computer science[1] are first introduced to the ISTE standards and their indicators and then asked to choose some of the indicators (up to 10) as their basic teaching directives. Mostly organized into groups of 3-4, the students work for some 45-60 minutes, after which a student from each group presents the chosen indicators. A brief summary of the students' proposals for the two academic years is given in Table 1.

Even though the list is short, this summary may be viewed as a good "iteration" towards a 10-indicator list. As an exercise, the reader may try to compile/make his/her own list of basic indicators. This exercise is particularly beneficial to those involved in pre-service and in-service professional development of mathematics teachers, especially when it focuses on issues that are subject to change. We find three reasons for such a claim. Firstly, it gives some personal meaning to the examined official proposals, the underlying reasons and assumed values of which are rarely fully explicated and therefore are not accessible to a wider public of teaching practitioners.[2] Secondly, this exercise increases the students'/teachers' motivation to reflect on their (future) profession and to apply such digested recommendations. Thirdly and finally, the exercise evidences that, contrary to typical mathematics lessons "one question - one answer", educational questions do not have unique solutions and frequently raise new questions. Thus, instead of obtaining final answers, the exercisers are becoming increasingly aware of the complexity of computer-based educational practice.

2000/2001 5 groups, 18 students listed are indicators chosen by at least three groups	2001/2002 9 groups, 33 students listed are indicators chosen by at least five groups
• Have good knowledge and skills and update them. • Use technology to increase productivity and solve problems. • Consider students' diverse backgrounds, characteristics and abilities. • Use technology to foster communication among all participants in the educational practice. • Use technology for assessment. • Develop positive attitudes toward computers.	• Stay in touch with the development of educational technology. • Use technology to foster logical thinking and creativity. • Use technology to affirm diversity. • Use technology to communicate with other colleagues, students and their parents.

Table 1. Students' proposals for basic ET indicators

Computer attitudes

As has already been underlined, computer attitudes influence both the acceptance of computers and their use as professional tools or teaching/learning assistants (see, for example, Woodrow, 1991). Computers will, therefore, be widely used in mathematics classrooms when teachers develop positive attitudes toward them, which can be achieved, at least to some extent. Having in mind that many studies have demonstrated that computer experience has a positive effect on computer attitude (see, for example, Kadijevich, 2000), positive attitudes would be developed

[1] A two-subject study group (mathematics & computer science)

[2] Consider the following issues: "Viewing curriculum reform as a technical rather than a moral and ethical process causes reformers to neglect not just basic questions but also the people who should be involved in answering them. Teachers, for example, may not be especially able to confront value dilemmas. They can be as stupid and short-sighted as anyone else. Their involvement is nonetheless essential." (Stanic & Kilpatrick, 1992, p. 415)

through proper computer activities. The author's experience with a group of first year students of geo-economics[3] suggests that extensive experiences with an able general-purpose environment such as *Microsoft Office*[4]— which coupled with *Microsoft Internet Explorer* helps teachers maintain various day-to-day activities like lesson preparation, students' administration, assessment preparation, report realization, e-mail communication, Web-site examination, etc. — may be an optimal solution to promoting positive computer attitudes. Of course, it may also be an optimal solution for teachers of other subjects, but multitasking with those *Microsoft* programs usually requires some degree of algorithmic thinking that is, because of their formal education, usually more familiar to mathematics teachers than to teachers of other subjects. Those who doubt that such a thinking is needed, since programming is not required here, may consider the author's ET indicator

> Promote/exercise thinking in terms of: (a) input and output data, (b) data that should/could be stored and queries that can be asked, and (c) modules the problem situation may be divided into

having in mind a work with *Microsoft* programs involving some text-processing, an Internet search, a spread-sheet handling and a database management (the purpose of which is producing a Web or slides-based presentation, for example).

Software selection and a proper utilization direction

Despite the fact that a mass of computer-based environments are available now at the educational market, it seems that less than 10 percent of this total may be given an "A grade" for quality (Neill & Neill, 1993). This figure may not be so discouraging as regards software for mathematics education, but it does raise the question of most appropriate software for the teaching/learning of mathematics. Although this question can be answered in many ways favouring various learning environments (especially in primary and middle grades), the author's experience as a mathematics teacher at a Gymnasium (a high school) suggests that secondary teachers may primarily base their classroom activities on a computer algebra system (CAS) and a dynamic geometry environment (DGE). Having in mind software cost, the availability and suitability of the accompanying literature on classroom activities as well as research findings, a good choice may be to use *DERIVE* and *CABRI Geometry* - two able products of the *Texas Instruments* company, whose demo versions can be downloaded from the TI Web-site (http://education.ti.com/parent/product/csw.html). It is true that one may question the educational value of CASs and DGEs because of some CASs' conceptual and procedural shortcomings (Kadijevich, 2002) as well as the fact that DGEs' drag-mode changes the traditional status of points and lines requiring new styles of reasoning (Hölzl, 1996), but their use does enable us to create and exploit learning environments that are more meaningful and thought-provoking than traditional ones. Note that a CAS such as *Scientific Notebook* produced by *MacKichan Software* (http://www.mackichan.com/) may be a suitable solution for those wishing to apply technology in the assessment process.

Other teachers and researchers may propose other able learning/teaching environments. But, regardless of which able learning environment is being used, students should not only improve their procedural and conceptual mathematical knowledge but also establish links between the two.

[3] By using a sample of 8 students whose computer attitudes were assessed by Selwyn's (1997) computer attitude scale translated into the Serbian language, it was found that almost within a month, after five 90-minute sessions with MS Office's programs Word, Excel and Power Point, the subjects' computer attitudes increased from 75.6 to 82.5 points (out of 105 points), which was a significant improvement ($t = 3.26$, $p = .014$; the Wilcoxon test: $Z = 2.52$, $p < .05$). The alpha reliability of the applied measure was acceptable (.84 before the treatment and .85 after it). Details of this pilot study can be found in Kadijevich (2002a).

[4] See http://microsoft.com/uk/education/, for example.

These links have rarely been studied and accomplished so far despite their high educational relevance (Kadijevich & Haapasalo, 2001). This seems to be quite a challenging aim in case of CAS or DGE.

Web-based professional development of mathematics teachers

Being aware of progress in educational technology, we find that a critical, balanced and well-designed use of computers in mathematics education requires a Web-based professional development for mathematics teachers to be utilized along with the traditional one. This claim is based upon the outcome of a recent project regarding such a Web-based development. This project was aimed to promote the *NCTM Professional Standards for Teaching Mathematics* (http://www.nctm.org/standards/), including but not focusing on technology. The project evidenced the following benefit to teachers: “consistent opportunities for reflection and sharing; a shortened cycle for training, implementation and evaluation; and teacher empowerment through direct access to information” (Shotsberger, 1999; p. 49). It is therefore important that mathematical faculties and professional organizations of mathematics teachers *also* support this form of professional development and maintain some appropriate Web sites focusing on technology-based mathematics education. These sites – the content of which may elaborate on the reported project (http://instruct.cms.uncwil.edu/) promoting the above-mentioned ISTE and NCTM standards – should, among others, critically inform their visitors of some programs, their usage and suitable classroom activities utilizing them. The usage of each program should be explained in form of a tutorial (see those placed at http://www.bcschools.net/staff/home.html or http://www.fgcu.edu/support/office2000/), which, within a few hours, enables a productive and successful practical work provoking further own experiences.

CODA

It seems that, even when computers are available, mathematics teachers rarely use them in their educational practice because they do not have (enough) knowledge and skills related to what and how can be achieved by using these tools (Manoucherhri, 1999). To change the present practice, we need to innovate, promptly yet thoughtfully, *both* pre-service and in-service professional development for mathematics teachers taking into account the four issues discussed above. In doing so, we should not forget that one’s learning results from a complex interplay among his/her cognitive, metacognitive and affective domains (see, for example, Schoenfeld, 1985), the last of which, based upon mathematics and computer attitudes, determines the global context where cognition (say ET-based mathematics teaching/learning) takes place monitored and controlled by metacognition (say ET and other learning/teaching standards).

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