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Computer use in mathematics teaching - overview of the situation in Serbia

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Abstract

In this study we analyse the quantity and the quality of the use of computers in mathematics teaching in schools (both primary and secondary) in Serbia, observing two samples. The data for the first research was obtained through a sample consisting of 142 experienced teachers. By conducting a survey we determined the current situation regarding personal and school use of computers, and also examined whether or not computer usage was affected by some non-attitudinal (e.g., demographic) and attitudinal variables. The second research included 123 beginner teachers, applicants for the professional state teacher license. The collected data was based on our estimates of the applicants' preparation for the practical part of the licensing examination. We examined the impact of some demographic and academic factors on the quality of computer usage. In both researches, the data collected was coded and analysed using the SPSS 13.0 statistical program (cross tabulation and appropriate tests for comparing groups). The aims of our researches were to determine the current situation and give some possible suggestions for improving computer use.

Key words: *beginner teachers, experienced teachers, quality of the computer use, quantity of computer use*

Introduction

The use of digital technologies, computer based applications, hardware and communication devices have become ubiquitous in modern society (Friedman, 2006). Contemporary generations that have been growing up on the wave of the technological revolution (which started several decades ago, and has reached every person in almost all segments of life by now) should not be taught only by means of paper-pencil or blackboard-chalk techniques. For these students, constant interaction using computers and contemporary technologies is definitely natural and that is why it should be used for improving the quality of teaching (Kebritchi, Hirumi, & Bai, 2010). Therefore, it is natural to expect that teachers, particularly young ones (who have graduated in the last ten years) use digital devices in their school practice (Cuban, 2001).

The aim of many researches across the globe was to examine the level of adequate use of computers for teaching and to determine the factors on which that usage depends among experienced and beginner teachers respectively (Rosen & Weil, 1995; Rusell & Bradley, 1997; Henry & Clements, 1999; Snoeyink, 2000; Sadik, 2006; Hsu, Wu, & Hwang, 2007; Lin, 2008; Smarkola, 2008; Starkey, 2010). Among others, Sime and Priestley (2005) identified in their research four categories of factors that predict whether teachers would integrate digital technologies into their teaching: resources available, experience in digital technologies, beliefs, and the context (including available support). Also, many authors investigated pre-service mathematics teachers' beliefs about using technology in mathematics teaching (Birgin, Çatlıoğlu, Coştu, & Aydın, 2009; Birgin, Çatlıoğlu, Gürbüz, & Aydın, 2010; Birgin, Çoker, & Çatlıoğlu, 2010). Researches at all levels of education show that Computer Assisted Instruction (CAI) is superior to traditional instruction in terms of the effects it has on learning mathematics (Tjaden & Martin, 1995; Gürbüz, 2007; Liao, 2007). Sadik (2006) indicates that teaching experience and training of teachers are vital for successful implementation and use of computers and that the acquisition of adequate competences will certainly enhance attitudes toward computers. Birgin et al. (2009) found that having experience in CAI and computer competence pose significant differences to the views of students of mathematics (future mathematics teachers) about computer assisted mathematics instruction. That study suggests that mathematics teacher education programmes should prepare students, future teachers, to teach tomorrow's students by using computers in the mathematics classroom effectively. Student teachers play crucial roles in integrating technology in schools (Baki, 2000; Teo, 2008).

Serbia is a south-eastern developing European country with a population of 7 million. For children between the ages of 6 and 15 years education is free and compulsory, and for children between the ages of 15 and 19 years education is free but not compulsory. The school system consists of preschool (age 6 years), primary (divided in two four year cycles, the first for ages 7-11 and the second for ages 11-15 years), and secondary (ages 15-19 years) schools. Our researches cover mathematics teachers in the second cycle of primary school and (all types of) secondary schools.

Until recently, in the Serbian educational system, Computer science had been studied only together with Mathematics. Because of that, we focus our analysis on estimates of the quantity and the quality of the computer usage in mathematics teaching in Serbia in both, primary and secondary schools. It is important to emphasize that the qualifications of mathematics teachers in primary and secondary schools are the same (Master of mathematics).

The aim of this paper is to determine:

- the level of computer usage in mathematics teaching in Serbia;
- the barriers and promoters of computer usage for mathematics teachers;
- possible ways for increasing and improving computer usage in mathematics teaching.

Based on many years of working with students who are preparing to be mathematics teachers and taking part in seminars for continuous education and professional development of teachers, as well as taking part in the State Commission for Teacher Licensing, we believe that we have a good insight into the current situation concerning mathematics education in Serbia. According to our experience, we think that computers are used insufficiently and inadequately in mathematics teaching in Serbia, in both primary and secondary schools. In our opinion the main reasons for that are lack of knowledge (of appropriate software) and skills related to using computers, as well as lack of positive attitudes towards using contemporary technologies in teaching, and, also, modest technical equipment in schools. Also, our hypotheses are that those teachers who use computers in the teaching process are significantly younger, have better academic achievements and more readily attend continuing education classes than those who do not use computers.

In order to test our hypotheses we have performed two researches. The first one is related to experienced teachers with the state teaching license, and the second is related to beginner teachers, who were in the process of obtaining the license.

Methodological approach

As mentioned previously, we carried out two independent researches. With respect to experienced teachers, we performed a survey during the annual seminar for continuing education of mathematics teachers in Serbia, organized by the Mathematical Society of Serbia. That is a traditional seminar gathering the greatest number of participants from all parts of Serbia. Our research included 142 mathematics teachers from both primary and secondary schools. The results of that research are based on their own answers. On the other hand, the research which included beginner teachers is based on data ensuing from our opinion of and grading of teachers' preparation for the practical part of the licensing examination (each applicant has to teach one lesson and provide a lesson plan). Therefore, these two researches are different in, at least, two ways:

- The sample in the first research consists of only licensed mathematics teachers, and the sample in the second research consists of only teachers who are in the process of obtaining license;
- The data in the first research was collected strictly by means of participants' self-evaluation. To the contrary, data in the second research was collected according to our evaluation of examinee's lesson preparation.

Collected data were analysed using the Statistical Package for Social Sciences (SPSS 13.0 for Windows).

Experienced teachers

In the survey, the teachers were asked to provide answers to questions about:

- Duration of working experience in school;
- Type of school;
- Number of hours spent in continuing education seminars over the last five years;
- Frequency of computer use for private purposes;
- Basic computer skills (Internet, E-mail, Microsoft Word, Microsoft Excel, and similar);
- Technical equipment at school (access to computers, access to the Internet, access to overhead projectors, and access to corresponding software);
- Frequency and manner of computer use in the teaching process;
- Reasons, in their opinion, for current level of computer use in teaching;
- Ways for enhancing computer use in the teaching process.

Beginner teachers

We have participated in the State Commission for Teacher Licensing during the last two years. That examination includes planning and executing one mathematics lesson in the school at which the applicant is not employed. We evaluated 123 such lessons. That experience gave us the ability to perceive the situation regarding computer use by beginner teachers.

We collected data about basic computer use for lesson plans and estimated the quality of text processing, drawing figures and typing mathematical formulas.

Results and discussion

Experienced teachers

The first research included 142 mathematics teachers with a professional license, 68 (47.89%) from primary and 74 (52.11%) from secondary schools. Their work experience ranged from 1 to 39 years; with the mean 17.16(±9.92) and the median 16.00 years (see Figure 1). Among the examinees, 124 of them provided information about the duration of their continuing education, measured in hours over the last five years (see Figure 2). The range of hours of continuing education was from 0 to 300, with the mean 90.40(±47.90) and the median 100.00.

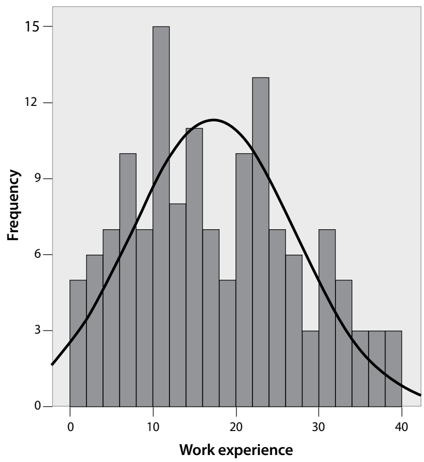

Figure 1. *Histogram of examinees' work experience*

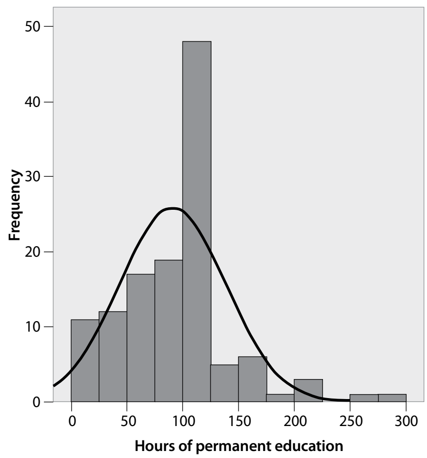

Figure 2. *Histogram of examinees' duration of continuing education*

Having in mind the above mentioned four categories of factors that predict whether teachers would integrate digital technologies into their teaching (Sime & Priestley, 2005) we investigated the number of teachers who have available computers in their schools. The situation is as follows:

- 94 (66.20%) participants answered that they had a computer available;
- 32 (22.53%) answered that they had a computer available, but for too many users, which implies lack of possibility of qualitative usage;
- 16 (11.27%) examinees answered that they did not have a computer available.

Although there is room for improving the issue of technical equipment, we have to conclude that the current level gives enough support for the use of computers in schools.

Sadik (2006) investigated the relationship between personal and school use of computers. He concluded that teachers who have positive attitudes towards their personal use of computers also feel positive towards the use of computers in schools. It was interesting for us to compare private to professional habits of teachers in terms of computer use. Based on the data collected, Figure 3 presents the results of the frequency of computer use for private purposes and in the teaching process.

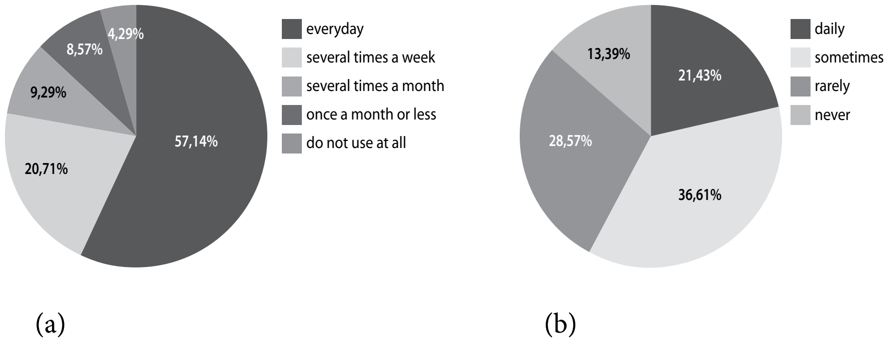

Figure 3. *Frequency of computer use for private purposes (a) and in the teaching process (b)*

By analysing and comparing the collected data, we point out that it is obvious that the frequency of using computers for professional purposes is significantly smaller than for private purposes. While 80 participants use computers on a daily basis for private purposes, only 24 of them use computers daily in their teaching. It can be observed that 15 participants answered that they do not use computers in teaching process in any way, but only 6 participants do not use computers at all.

When discussing the manner in which computers are used in teaching, one of the questions was related to the types of teaching materials in electronic forms which they possess personally or share with colleagues at school. They had to mark one or more of the following five options:

(1) Collections of teaching units in the electronic form (77 participants);
(2) Some kind of educational software (34 participants);
(3) Presentations or video films for some parts of teaching units (56 participants);
(4) Collections of control or final tests (59 participants);
(5) Nothing of the above (10 participants).

According to the data collected, we got the results presented in Table 1 about the manner in which computers were used in the teaching process, where number 1 means that the participants marked only 1, number 13 means that the participants marked only 1 and 3 etc.

Table 1. *The manner of computer use in the teaching process*

	Frequency	Percent	Valid Percent
1	14	9.9	10.6
2	3	2.1	2.3
3	10	7.0	7.6
4	26	18.3	19.7
5	18	12.7	13.6
13	2	1.4	1.5

14	13	9.2	9.8
23	3	2.1	2.3
24	3	2.1	2.3
34	4	2.8	3.0
123	4	2.8	3.0
124	4	2.8	3.0
134	11	7.7	8.3
234	6	4.2	4.5
1234	11	7.7	8.3
Total	132	93.0	100.0
Missing System	10	7.0	
Total	142	100.0	

As can be seen from Table 1 we can conclude that teachers mainly use computers as "clever notebook", i.e., only as storage of materials which can be reused or easily modified before some new use. Additionally, we see that 98 (69.01%) participants marked 1 or 4, but only 34 (23.94%) use computers at an advanced level (which among the others means use of some kind of educational software).

Partculary, our interest was in the use of CAS (Computer Algebra Systems) and/or IG (Interactive Geometry) tools. Although CAS and IG tools are the most effective and most desirable way of using computers in mathematics teaching (from our point of view), unfortunately, that usage is quite rare, only 15 (10.56%) of the 142 participants indicate that they use them. This is one more item which is in line with our observation about inadequate use of computers in the teaching process. We can observe similar results obtained by Sadik (2006), who determined that there is high use of computers for low-level purposes (e.g. word processing and playing audio recordings), while the use of computers for programming and courseware design was the least used purpose for teachers.

As the main obstacles for their better and/or more frequent use of computers in teaching, teachers specify the following:

1. Absence of adequate equipment in schools – 36 (25.35%) participants;
2. Lack of knowledge in computer use, or use of appropriate software – 17 (11.97%) participants;
3. Their negative attitude towards using computers in the teaching process – 11 (7.75%) participants.

It can be observed that the listed obstacles correspond to the factors that have already been identified in other researches (Sime & Priestley, 2005; Starkey, 2010).

Consistent with the above mentioned obstacles, the ways for enhancing computer use in teaching are, according to the teachers' opinions, the following:

1. Better technical equipment in schools – 84 (59.15)% participants;
2. Continuing education of teachers – 75 (52.82%) participants;
3. More available software – 50 (35.21%) participants;
4. More help from State authorities – 34 (23.94%) participants.

Our opinion is that significant improvement (in both quality and quantity), with the existing level of equipment, could be achieved by insisting on continuing education of teachers. It is probably the most efficient way considering that it gives good results in a short time frame while using modest material support.

At the end of this part, some statistical analysis of collected data, conducted in order to check the validity of the hypothesis given in Introduction will be presented. The following conclusions were reached.

1. A 2×2 contingency table analysis was conducted to determine if there is an association between the use of computers in the teaching process and the type of school. The Chi-Square test with Yates' Correction for Continuity did not show a significant relationship between the use of computers and the type of school, $\chi^2(1, n=142)=0.000$, $p=1.000>0.05$ (see also Figure 4). This is expected since mathematics teachers in primary and secondary school have the same education.

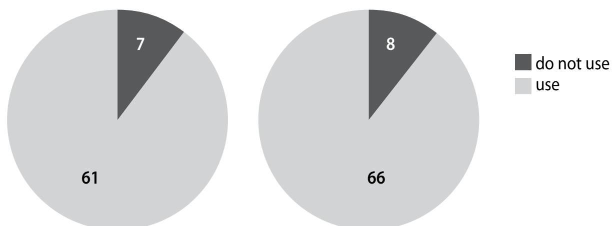

Figure 4. *Use of computers in primary (left) and secondary (right) school*

2. Mann-Whitney U test indicates that there is a significant difference between average work experience in populations of teachers who use (Md=15, n=126) and who do not use computers in the teaching process (Md=23, n=15), Z=–2.275, $p=0.023<0.05$ (see Figure 5), thus verifying our hypothesis that those who use computers in teaching more frequently are younger teachers.

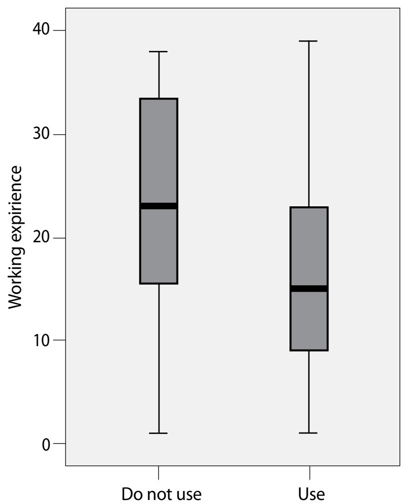

Figure 5. *Box plots presenting work experience in the two observed groups*

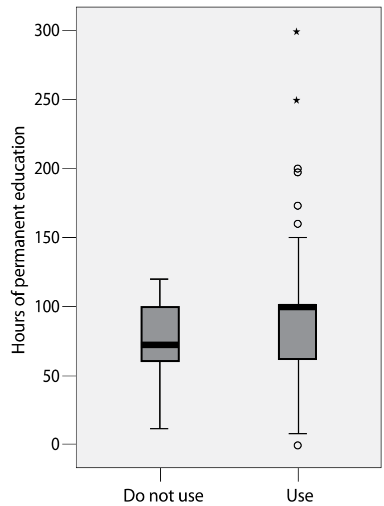

Figure 6. *Box plots presenting duration of permanent education in the two observed groups*

3. The conducted Mann-Whitney U test suggests that there is no significant difference between the average duration of continuing education in populations of teachers who use (Md=100, n=111) and those who do not use computers (Md=72, n=13) in the teaching process Z=–0.896, p=0.37>0.05 (see Figure 6). However, it is important to observe that all of the participants who have spent a significant number of hours in continuing education (more then 120) use computers in the teaching process, which is, to an extent, in line with the results from previous researches indicating that in-service training of teachers is very important for a successful implementation and use of computers in the teaching process (Sadik, 2006; Yildirim 2000).

Beginner teachers

The second research covered 123 beginner mathematics teachers – applicants for the professional license, 80 (65.00%) from primary and 43 (35.00%) from secondary schools. Since the State Commission is unique, we have examinees who have graduated from various state universities (66 graduated from University of Belgrade, 17 from University of Novi Sad, 19 from University of Niš, 16 from University of Kragujevac, and 5 graduated from some other university) and who are working in all regions of Serbia (39 in Belgrade, 23 in Vojvodina, 30 in central and west Serbia, and 31 in south and east Serbia). Thus, the sample adequately represents the state of mathematics education in Serbia.

It is important to emphasize that beginner teachers are novice in teaching profession (some of them previously worked in some other positions). A condition necessary for applying for the teaching license is one year of work experience as mathematics teacher. The data regarding the age of the applicants is presented in Figure 7, the mean is 34.73(±5.73) and the median is 34.00.

The research conducted for this purpose relates to one part of the licensing examination, precisely to mathematics lessons performed by applicants in schools. In this research we only concentrated on the achieved level of technical processing of prepared lesson plans (here we ignore the quality of the lesson plan itself). As this is the main part of a very important examination for applicants, it is quite natural to expect that the technical processing of the given lesson plan is not of lesser quality than in everyday school practice. We evaluated the quality of technical processing according to three categories: unsatisfactory, satisfactory, and good.

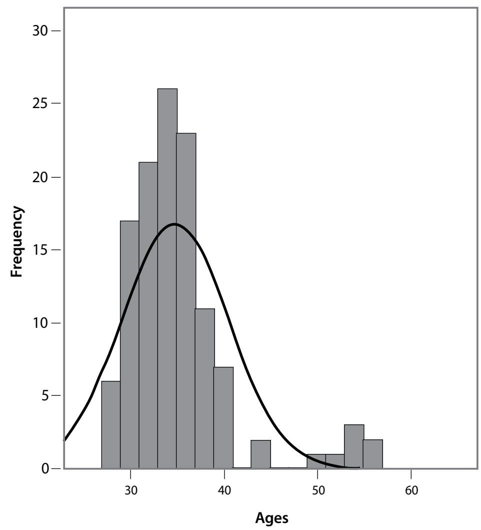

Figure 7. *Histogram of examinees' ages*

From the data collected, we established that 8 (6.50%) of the examinees did not use a computer at all (their lesson plans were written by hand). The marks, based on our opinion, for the 115 examinees who used computers for text processing are given in Table 2.

Among the observed population, there were 60 teachers who had figures in their lesson plans, but 17 of them drew figures by hand. The marks for the others are given in Table 3. Also, the marks for typing mathematical formulas are given in Table 4 (notice that 2 examinees wrote the formulas by hand).

Table 2. *Evaluation of examinees' text processing*

	Frequency	Percent
Unsatisfactory	10	8.7
Satisfactory	52	45.2
Good	53	46.1
Total	115	100.0

Table 3. *Evaluation of examinees' drawing figures by using computers*

	Frequency	Percent
Unsatisfactory	21	48.8
Satisfactory	16	37.2
Good	6	14.0
Total	43	100.0

Table 4. *Evaluation of examinees' typing of mathematical formulas*

	Frequency	Percent
Unsatisfactory	50	44.2
Satisfactory	33	29.2
Good	30	26.6
Total	113	100.0

We were interested in checking whether there were any connections between the university from which the applicants graduated (we took into account only four major state universities), the region where they work, the type of school where they teach, average marks during study, duration of study and, on the other hand, the characteristics of their lesson plans which we evaluated. Based on the statistical analysis of the collected data we have obtained results which we present in the continuation.

Regarding the connection between the use of computers in the teaching process and the university from which the examinees graduated we obtained the results presented in Table 5. A 4×3 contingency table analysis was conducted to determine if there is an association between the use of computers (marks 1, 2, and 3) for text processing and the university from which the examinees graduated. The Chi-Square test did not show a significant relationship between computer use and university, Pearson Chi-Square value (6, 110)=6.374, $p=0.383>0.05$. Since contingency tables in two other cases contain too many cells that have entries less than 5, the Chi-square test could not be conducted. But, according to Table 5, it seems that the university attended does not play a crucial role in the quality of drawing figures and typing mathematical formulas.

Table 5. *Evaluated characteristics of examinees' lesson plans according to universities*

University	Belgrade				Novi Sad				Niš				Kragujevac			
Marks	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Text processing	5	7	30	24	2	1	3	11	1	1	8	9	0	1	8	7
Drawing Figures	7	15	11	4	3	0	1	0	3	2	0	2	4	2	3	0
Typing formulas	1	34	16	10	0	4	3	8	0	6	7	5	1	4	5	6

Note: 0 – by hand; 1 – unsatisfactory; 2 – satisfactory; 3 – good.

Table 6. *Evaluated characteristics of examinees' lesson plans according to regions*

University	Belgrade				Vojvodina				Central and west Serbia				South and east Serbia			
Marks	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Text processing	3	6	16	14	3	2	5	12	0	1	17	12	2	1	13	15
Drawing Figures	5	7	5	2	5	2	1	0	4	6	5	1	3	6	5	3
Typing formulas	1	18	10	7	0	7	5	7	1	12	7	10	0	12	11	6

Note: 0 – by hand; 1 – unsatisfactory; 2 – satisfactory; 3 – good.

Table 6 shows marks for the evaluated characteristics with respect to regions in Serbia. A 4×3 contingency table analysis was conducted to determine if there is a link between the quality of text processing as well as the quality of typing mathematical formulas and regions where beginner teachers work. The Chi-Square tests show that both the quality of text processing and the quality of typing mathematical formulas are independent of the region of Serbia where novice teachers work:

- Pearson Chi-Square value (6, 114)=8.995, $p=0.174>0.05$ (text processing);
- Pearson Chi-Square value (6, 112)=4.174, $p=0.653>0.05$ (typing formulas).

In the case of drawing figures, the Chi-square test could not be conducted, however, it seems that there is no significant difference between the regions as well.

Table 7. *Evaluated characteristics of examinees' lesson plans according to types of school*

School type	Primary				Secondary			
Marks	0	1	2	3	0	1	2	3
Text processing	5	6	33	36	3	4	19	17
Drawing figures	13	18	12	3	4	3	4	3
Typing formulas	2	39	19	15	0	11	14	15

Note: 0 – by hand; 1 – unsatisfactory; 2 – satisfactory; 3 – good.

A 2×3 contingency table analysis was conducted to determine if there is an association between the quality of text processing as well as the quality of typing mathematical formulas and the types of schools where teachers work. The quality of text processing is independent of the type of school, Pearson Chi-Square value (2, 115)=0.362, $p=0.834>0.05$. However, the quality of typing mathematical formulas and the types of schools are correlated, Pearson Chi-Square value (2, 113)=7.434, $p=0.024<0.05$. The situation in secondary schools is better than in primary schools (see Figure 8).

In the case of drawing figures the Chi-square test could not be conducted.

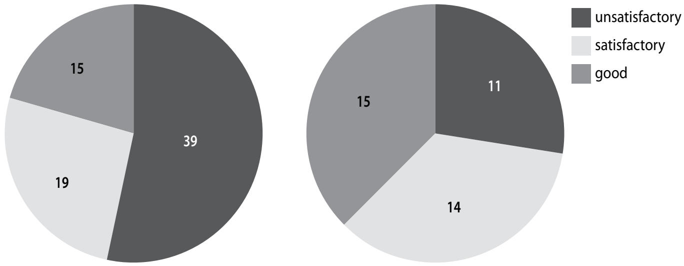

Figure 8. *Quality of typing mathematical formulas in primary (left) and secondary (right) school*

The presented data and the analyses speak in favour of our previously mentioned opinion that the situation is unsatisfactory and overall the same in all schools in Serbia.

We conducted the Kruskal-Wallis tests to check if there are significant differences in average marks during the course of the study for the observed populations (with differently evaluated characteristics).

- There are significant differences in the average marks during the course of the study between populations of beginner teachers who wrote the text by hand (Md=7.92, n=8), whose text processing is unsatisfactory (Md=7.35, n=10), satisfactory (Md=7.52, n=52), or good (Md=7.95, n=52), $\chi^2(3, n=122)=14.762$, $p=0.002<0.05$. Specifically, using the Mann-Whitney U tests, there is a significant difference between populations whose text processing is unsatisfactory and good (Z=–2,422, $p=0.015<0.05$), as well as between populations whose text processing is satisfactory and good (Z=–3,502, $p=0.000<0.05$), see Figure 9.
- There are significant differences in average marks in the study between populations of those who draw figures by hand (Md=7.84, n=17), unsatisfactory (Md=7.35, n=21), satisfactory (Md=7.91, n=16) and good (Md=8.14, n=6), use computers for drawing, $\chi^2(3, n=60)=10.333$, $p=0.016<0.05$. Specifically, using the Mann-Whitney U tests, there is a significant difference between populations of those who draw figures by hand and those who use computers in an unsatisfactory way (Z=–2.144, $p=0.031<0.05$), as well as between populations of those who use computers in an unsatisfactory and satisfactory way (Z=–2.055, $p=0.04<0.05$), and also populations of those who use computers in an unsatisfactory and good way (Z=–2.655, $p=0.005<0.05$), see Figure 10.
- There are significant differences in average marks in the study between populations of those who write mathematical formulas by hand (Md=7.39, n=2), unsatisfactory (Md=7.58, n=50), satisfactory (Md=7.80, n=32) and good (Md=9.12, n=30) use computers for typing mathematical formulas, $\chi^2(3, n=114)=10.358$, $p=0.016<0.05$. Specifically, using the Mann-Whitney U test, there is a significant difference between the population of those who use computers in an unsatisfactory and good way (Z=–2.922, $p=0.003<0.05$), see Figure 11.

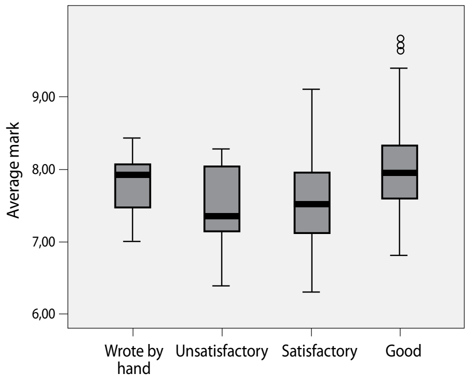

Figure 9. *Box plots presenting average marks during study and quality of text processing*

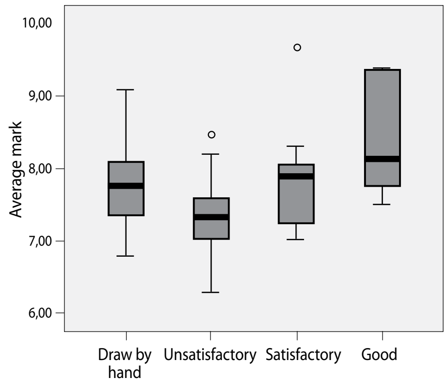

Figure 10. *Box plots presenting average marks during study and quality of drawing figures*

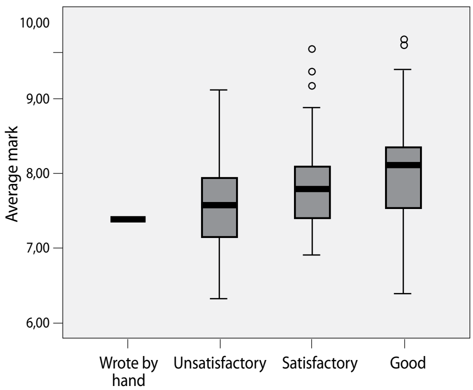

Figure 11. *Box plots presenting average marks during study and quality of typing mathematical formulas*

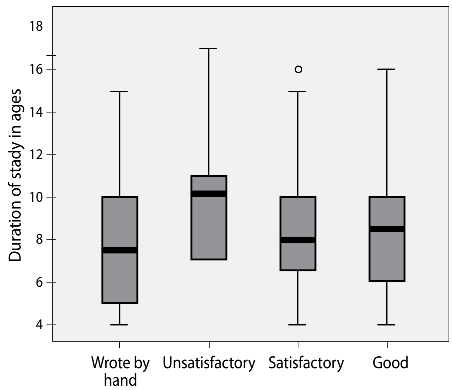

Figure 12. *Box plots presenting duration of study and quality of text processing*

With respect to the participants' length of the study, the following results were obtained:

- The conducted Kruskal-Wallis test, $\chi^2(3, n=118)=2.648$, $p=0.449>0.05$, does not suggest that there are statistically significant differences in the length of study between populations of those who wrote the text by hand (Md=7.50, n=8) or those whose text processing is unsatisfactory (Md=10.00, n=9), satisfactory (Md=8.00, n=51) and good (Md=8.50, n=50), see Figure 12.
- The conducted Analysis of Variance (ANOVA) does not suggest that there are statistically significant differences in the length of study between populations of examinees who draw figures by hand (8.13±0.786, n=15), unsatisfactory (9.65±0.650, n=20), satisfactory (8.38±0.576, n=16) and good use computers for drawing (7.17±1.078, n=6), $F(3, 53)=1.675$, $p=0.183>0.05$, see Figure 13.
- The conducted Kruskal-Wallis test ($\chi^2(3, n=110)=1.544$, $p=0.672>0.05$) does not suggest that there are statistically significant differences in the length of study between populations of examinees who write mathematical formulas by hand (Md=9.50, n=2),

unsatisfactory (Md=8.50, n=48), satisfactory (Md=9.00, n=32) and good (Md=8.00, n=30) use computers for typing mathematical formulas (see Figure 14).

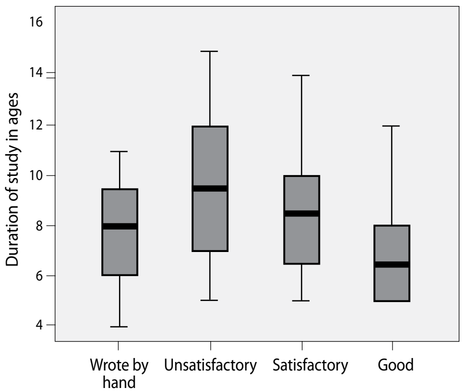

Figure 13. *Box plots presenting duration of study and quality of drawing figures*

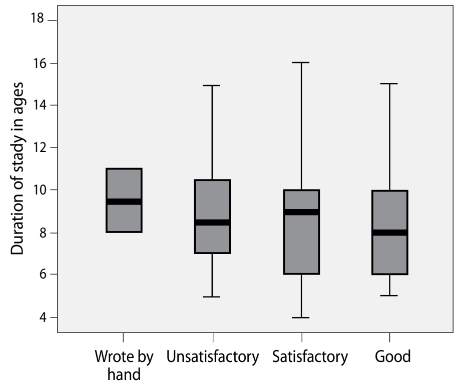

Figure 14. *Box plots presenting duration of study and quality of typing mathematical formulas*

The presented data and analyses imply that teachers with higher academic achievements in their studies usually use computers in a more adequate way. This suggests, also, that the studies are the most important part of teachers' education, when a solid foundation for appropriate use of computers in teaching process must be established. We must have this in mind when developing curricula and/or university course programmes. Lin (2008) also recommends that mathematics teacher education programmes be reviewed taking into consideration students' needs and also preparing future teachers for effective use of technology in mathematics teaching.

Also, it is interesting to notice that beginner teachers who wrote the text by hand as well as those who drew figures by hand have better average marks than those who use computers for that purpose in an unsatisfactory way. In our opinion, the reason for that is a lack of positive attitude towards using digital technologies in teaching.

Conclusion

In the two independent researches we investigated the use of computers in the teaching process in Serbia, one relating to experienced teachers with a state teaching license, and the other relating to beginner teachers, applicants for the license. We were interested in determining the level of computer use, the current situation and reasons behind it, as well as the ways for increasing and improving computer use.

The first important result of our research is that the difference between computer use for private and professional purposes is too big, and the level of use for private purposes provides a possibility for a fast increase of computer use in the teaching process. In our opinion, the reasons for such a difference are the following: (1) from the teachers' point of view computer-based teaching is a kind of innovation bringing certain difficulties (Henry, & Clements, 1999); (2) the teacher's role should no longer be that of a traditional lecturer (Hsu, Wu, & Hwang, 2007). Therefore, teachers do not have a resistance to digital technologies at all, but it is obvious that they are not sure about the ways of implementing them in the teaching processes.

As it was expected, younger teachers are leading the way in using computers in the teaching process. Besides that, our studies show that the main impacts on the use of computers in the teaching process lie in the average marks during the teachers' course of study as well as their dedication to continuing education. It can be observed that the level and the quality of computer use do not depend on the university from which the teachers had graduated or on the place of work (in both sense, type of school and less or more economically developed region).

The results obtained have further convinced us that teacher education is a strategically critical period during which improvements, i.e. effective integration of computers into the curriculum have to be made. Learning to teach mathematics with technology is best learned when technology is integrated into the teacher education curriculum (Baki, 2000). Students with positive attitudes towards mathematical computer tools overcame initial difficulties when using such tools and progressed to more effective behaviours (Pierce, & Stacey, 2004; Reed, Drijvers, & Kirschner, 2010). During their education (both basic and continuing) teachers should be encouraged to develop the right attitude and become qualified to use newly developed digital tools for teaching. The term *being qualified* implies not only providing teachers with opportunities to learn about new technologies (knowledge), but also to learn about when and how to use them in teaching (skill). We see a possible solution in providing a wider range of topics directly related to school practice in didactics courses at teaching faculties which would help future teachers deal with multiple problems that they may encounter in their practice. Also, we suggest restructuring of the existing courses in such a way that they encourage the use of digital technologies which can improve the quality of teaching process.

Several years ago at some universities in Serbia a course named *Educational Software* was included in the mathematics curriculum. That course was intended to increase the interest for software packages, especially for CAS-IG tools, as well as develop positive attitudes for using contemporary technologies in teaching. Students received examples of those parts of mathematics where the corresponding software packages could be applied in teaching. This decision will mostly influence, in our opinion, those future teachers, students who will graduate in the years to come; they will influence the change of the attitude regarding the use of digital technologies in the teaching process. Serious research which is to follow our graduated students in longer time period, if we talk about their professional work, may give the answers with greater accuracy about the questions being asked.

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Uporaba računala u poučavanju matematike – pregled stanja u Srbiji

Sažetak

U ovom radu analiziramo kvantitetu i kvalitetu uporabe računala u poučavanju matematike u Srbiji (u osnovnim i srednjim školama) promatrajući dva uzorka. Podaci za prvo istraživanje prikupljeni su na uzorku od 142 iskusna nastavnika (s profesionalnom licencom). Provedbom istraživanja ustanovili smo trenutnu situaciju s obzirom na privatnu uporabu računala i uporabu računala u školi, kao i utječu li na uporabu računala neke objektivne (npr. demografija) i subjektivne varijable. Drugo istraživanje je provedeno na uzorku od 123 nastavnička pripravnika (bez profesionalne licence). Prikupljeni podatci su temeljeni na našim procjenama o pripravi praktičnog dijela stručnog ispita pripravnika. Istražili smo utjecaj nekih demografskih i akademskih čimbenika na kakvoću uporabe računala. U oba istraživanja podatci su obrađeni uporabom statističkog programa SPSS 13.0 (unakrsno tabeliranje i odgovarajući testovi za uspoređivanje skupina). Cilj istraživanja je bio utvrditi trenutnu situaciju i predložiti moguća poboljšanja uporabe računala.

***Ključne riječi**: nastavnik pripravnik, iskusni nastavnik, kakvoća uporabe računala, kvantiteta uporabe računala*

Uvod

Uporaba digitalnih tehnologija, računalnih aplikacija, hardvera i komunikacijske opreme postala je uobičajena u modernom društvu (Friedman, 2006). Suvremene generacije, koje odrastaju na valu tehnološke revolucije (koja je započela prije nekoliko desetljeća i utjecala na ljude u skoro svim područjima djelovanja), ne bi se trebale poučavati samo uporabom pomagala kao što su olovka-papir ili ploča-kreda. Za te učenike potpuno je prirodna stalna interakcija s računalom i stoga bi ju trebalo iskoristiti za unaprjeđivanje kakvoće procesa učenja i poučavanja (Kebritchi, Hirumi, & Bai, 2010). Shodno tome očekuje se da se nastavnici, a posebno mlađa generacija (koja je diplomirala unazad deset godina) koriste digitalnim uređajima u svojoj nastavi (Cuban, 2001).

Cilj mnogih istraživanja diljem svijeta bio je utvrditi razinu prikladne uporabe računala u nastavi i čimbenike o kojima ta uporaba ovisi među početnicima i iskusnim nastavnicima (Rosen & Weil, 1995; Rusell & Bradley, 1997; Henry & Clements, 1999; Snoeyink, 2000; Sadik, 2006; Hsu, Wu, & Hwang, 2007; Lin, 2008; Smarkola, 2008; Starkey, 2010). Među ostalima, Sime i Priestley (2005), su u svom istraživanju identificirali četiri kategorije čimbenika koji predviđaju hoće li nastavnici integrirati digitalne tehnologije u svoju nastavu: dostupna sredstva, iskustvo uporabe digitalnih tehnologija, uvjerenja, i kontekst (uključujući i raspoloživu potporu). Mnogi autori su istraživali i stavove o uporabi računala u nastavi matematike među studentima nastavničkog smjera matematike (Birgin, Çatlıoğlu, Coştu, & Aydın, 2009; Birgin, Çatlıoğlu, Gürbüz, & Aydın, 2010; Birgin, Çoker, & Çatlıoğlu, 2010). Istraživanja na svim razinama obrazovanja pokazuju da je računalno potpomognuta nastava (*Computer Assisted Instruction - CAI*), s obzirom na učinke pri učenju matematike, superiornija u odnosu na tradicionalne metode (Tjaden & Martin, 1995; Gürbüz, 2007; Liao, 2007). Sadik (2006) ukazuje na to da su nastavničko iskustvo, kao i obrazovanje nastavnika, vitalni za uspješnu implementaciju i uporabu računala te da usvajanje odgovarajućih kompetencija zasigurno pospješuje pozitivne stavove prema računalima. Birgin i dr. (2009) su ustanovili da iskustvo u CAI i računalna kompetencija predstavljaju značajnu razliku u pogledima studenata matematike (budućim nastavnicima) prema računalno potpomognutoj nastavi matematike. Taj rad predlaže da program obrazovanja nastavnika matematike, studente, buduće nastavnike, treba pripremiti da s učenicima sutrašnjice učinkovito upotrebljavaju računala u nastavi matematike. Budući nastavnici igraju ključnu ulogu u uključivanju tehnologije u škole (Baki, 2000; Teo, 2008).

Srbija je jugoistočna europska zemlja u razvoju s populacijom od 7 milijuna stanovnika. Školovanje je besplatno i obvezatno za djecu između 6 i 15 godina, a besplatno ali ne i obvezatno za djecu od 15 do 19 godina starosti. Obrazovni sustav se sastoji od predškole (6 godina starosti), osnovne škole (podijeljeno na dva četverogodišnja ciklusa, prvi od 7-11 godina i drugi od 11-15 godina starosti) i srednje škole (15-19 godina starosti). Naše istraživanje se odnosi na nastavnike matematike drugog ciklusa osnovne škole i (svih tipova) srednjih škola.

Sve donedavno računalne su se znanosti u srbijanskom školskom sustavu izučavane zajedno s matematikom. Zbog toga smo naše istraživanje usredotočili na procjenu količine i kakvoće uporabe računala u nastavi matematike na osnovnoškolskoj i srednjoškolskoj razini. Bitno je naglasiti da nastavnici matematike u osnovnim i srednjim školama imaju jednake kvalifikacije (diplomirani matematičar).

Cilj ovog rada je utvrditi:

- razinu uporabe računala u poučavanju matematike u Srbiji
- prepreke i poticaje nastavnicima matematike pri uporabi računala
- mogući načini povećanja i poboljšanja uporabe računala u poučavanju matematike.

Temeljem niza godina rada sa studentima koji se spremaju postati nastavnici matematike te sudjelovanjem na seminarima kontinuiranog obrazovanja i stručnog usavršavanja, kao i sudjelovanjem u Državnoj komisiji za licenciranje nastavnika, vjerujemo da imamo dobar uvid u trenutnu situaciju matematičkog obrazovanja u Srbiji. Prema dosadašnjem iskustvu smatramo da se računala u nastavi matematike osnovnih i srednjih škola Srbije ne upotrebljavaju dovoljno niti na odgovarajuće načine. Mislimo da je glavni razlog tome nedostatak znanja (uporabe odgovarajućeg softvera) i vještina koje se odnose na uporabu računala, kao i pomanjkanje pozitivnih stavova prema uporabi suvremenih tehnologija u nastavi te skromnoj tehničkoj opremljenosti škola. Također, naša je hipoteza da su nastavnici koji u nastavi upotrebljavaju računala značajno mlađi, imaju bolja akademska postignuća te spremno pohađaju nastavu kontinuiranog usavršavanja, za razliku od onih koji u nastavi ne upotrebljavaju računala.

Kako bismo provjerili naše hipoteze, proveli smo dva istraživanja. Prvo se odnosi na iskusne nastavnike s položenim državnim stručnim ispitom, a drugo na nastavnike-početnike koji su u procesu polaganja državnog stručnog ispita.

Metodologija istraživanja

Kao što smo naveli, proveli smo dva neovisna istraživanja. S iskusnim nastavnicima istraživanje smo proveli za vrijeme godišnjeg seminara kontinuiranog usavršavanja nastavnika matematike u Srbiji, koji organizira Društvo matematičara Srbije. To je tradicionalni seminar koji okuplja najveći broj sudionika iz svih krajeva Srbije. Naše istraživanje je obuhvatilo 142 nastavnika matematike osnovnih i srednjih škola. Rezultati tog istraživanja utemeljeni su na njihovim odgovorima. S druge strane, rezultati istraživanja koje smo proveli s nastavnicima početnicima temeljeni su na podatcima proizašlim iz našeg mišljenja i ocjena nastavničke priprave i nastavnog sata izvedenog temeljem te priprave u sklopu polaganja državnog stručnog ispita (svaki pristupnik mora izvesti jedan javni sat i priložiti pisanu pripravu za taj sat). S obzirom na navedeno, ta dva istraživanja se razlikuju najmanje na dva načina:

Uzorak u prvom istraživanju sastavljen je isključivo od nastavnika matematike s položenim državnim stručnim ispitom, dok je uzorak u drugom istraživanju sastavljen isključivo od nastavnika koji su u procesu polaganja državnog stručnog ispita.

Podatci iz prvog istraživanja prikupljeni su isključivo samovrjednovanjem ispitanika. U drugom slučaju podaci su bili rezultat naše evaluacije priprave ispitanika za izvođenje nastave.

Prikupljeni podatci su obrađeni uporabom Statističkog paketa za društvene znanosti (SPSS 13.0 for Windows).

Iskusni nastavnici

Istraživanje je od nastavnika tražilo da odgovore na pitanja:
- godine radnog iskustva u školi
- vrsta škole u kojoj rade
- broj sati provedenih na seminarima kontinuiranog obrazovanja tijekom zadnjih pet godina

- učestalost uporabe računala za osobne potrebe
- osnovne računalne vještine (internet, e-pošta, Microsoft Word, Microsoft Excel, i sl.)
- tehnička opremljenost u školi (pristup računalima, pristup internetu, pristup grafoskopima, i pristup odgovarajućem softveru)
- učestalost i način uporabe računala u nastavnom procesu
- razlozi, prema njihovom mišljenju, za trenutnu razinu uporabe računala u nastavi
- na koje načine bi se uporaba računala u nastavom procesu mogla poboljšati.

Nastavnici početnici

Tijekom posljednje dvije godine sudjelovali smo u Državnom povjerenstvu za provedbu stručnih ispita. Ispit se sastoji od planiranja i izvođenja jednog nastavnog sata matematike u školi u kojoj pristupnik nije zaposlen. Izvršili smo evaluaciju 123 takva predavanja. To iskustvo nam je omogućilo uvid u stanje stvari vezano za uporabu računala kod nastavnika početnika.

Prikupili smo podatke o osnovnoj uporabi računala pri izradi priprava za izvođenje nastavnog sata te s njima procijenili kakvoću obrade teksta, grafičkih prikaza i unosa matematičkih formula.

Rezultati rasprava

Iskusni nastavnici

Prvo istraživanje je obuhvatilo 142 nastavnika matematike s položenim državnim stručnim ispitom, 68 (47,89%) iz osnovne škole i 74 (52,11%) iz srednje škole. Radno iskustvo je bilo u rasponu od 1 do 39 godina; prosječna vrijednost 17,16 (±9,92) i srednja vrijednost (medijana) 16,00 godina (vidi Slika 1). Među ispitanicima 124 ih je dalo informaciju o trajanju njihova kontinuiranog obrazovanja, mjereno u satima tijekom posljednjih pet godina (vidi Sliku 2). Raspon sati se kretao od 0 do 300, s prosječnom vrijednošću 90,40 (±47,90) i srednjom vrijednošću (medijanom) 100,00.

Slika 1.

Slika 2.

Imajući na umu gore navedene četiri kategorije čimbenika koji su predviđali hoće li nastavnici integrirati digitalne tehnologije u poučavanje (Sime & Priestley, 2005) istražili smo broj nastavnika kojima su dostupna računala u školi. Situacije je sljedeća:

- 94 (66,20%) ispitanika je odgovorilo da imaju dostupno računalo u školi;
- 32 (22,53%) je odgovorilo da imaju pristup računalu, no ono je dostupno prevelikom broju korisnika, što smanjuje mogućnost kvalitetne uporabe;
- 16 (11,27%) ispitanika je odgovorilo da nemaju dostupno računalo.

Iako postoji prostor za poboljšanje stanja tehničke opremljenosti, moramo zaključiti kako trenutna razina opremljenosti daje zadovoljavajuću potporu uporabi računala u školama.

Sadik (2006) je istraživao vezu između osobne uporabe računala i uporabe računala u školi. Zaključio je da nastavnici koji imaju pozitivan stav prema osobnoj uporabi računala, takav odnos imaju i prema uporabi računala u školama. Bilo nam je zanimljivo uspoređivati privatne i poslovne navike uporabe računala kod ispitanika. Temeljem prikupljenih podataka, Slika 3 predstavlja učestalost uporabe računala u privatne svrhe i u nastavnom procesu.

Slika 3.

Analizirajući i uspoređujući prikupljene podatke ističemo da je očita značajno manja učestalost uporabe računala u poslovne nego u osobne svrhe. Dok 80 sudionika računalo upotrebljava svakodnevno za osobne potrebe, samo 24 njih računalo upotrebljava svakodnevno u nastavne svrhe. Pripominjemo da je 15 sudionika odgovorilo kako uopće ne upotrebljavaju računala u nastavi ni na koji način, ali samo 6 sudionika je izjavilo da računala uopće ne upotrebljavaju.

Razmatrajući pitanje načina uporabe računala u poučavanju, jedno od pitanja se odnosilo na tipove nastavnih materijala u elektroničkom obliku koji posjeduju osobno ili zajednički s kolegama u školi. Trebali su označiti jednu ili više od pet navedenih mogućnosti:

(1) Zbirku nastavnih jedinica u elektroničkom obliku (77 sudionika)
(2) Neku vrstu obrazovnog softvera (34 sudionika)
(3) Prezentacije ili videozapise za neke dijelove nastavnih jedinica (56 sudionika)
(4) Zbirku kontrolnih ili završnih ispita (59 sudionika)
(5) Ništa od navedenog (10 sudionika).

Prema prikupljenim podatcima, dobili smo rezultate o načinu uporabe računala u nastavnom procesu prikazane u Tablici 1, gdje broj 1 označava da su ispitanici označili samo 1, broj 13 da su označili samo 1 i 3 itd.

Tablica 1.

Kao što se vidi iz Tablice 1, možemo zaključiti da nastavnici računala koriste uglavnom kao "pametnu bilježnicu", npr. samo kao spremište za materijale koji mogu biti ponovno upotrijebljeni ili jednostavno izmijenjeni prije neke ponovne uporabe. K tomu vidimo da je 98 (69.01%) sudionika označilo 1 ili 4, ali samo 34 (23,94%) računalom se koristi na naprednijoj razini (koja, između ostalog, podrazumijeva uporabu i neke vrste obrazovnog softvera).

Posebno nas je zanimala uporaba CAS (Computer Algrebra Systems – Sustava za računalnu algebru) i/ili IG (Interactive Geometry – Interaktivna geometrija) alata. Iako su CAS i IG alati najučinkovitiji i najpoželjniji načini uporabe računala u poučavanju matematike (s naše točke gledišta), na nesreću, takva uporaba je prilično rijetka, samo 15 (10,56%) od 142 ispitanika su potvrdili da koriste navedene alate. To je samo još jedna stavka na tragu naše opaske o neadekvatnosti uporabe računala u procesu poučavanja. Slične rezultate možemo primijetiti kod Sadika (2006) koji je utvrdio visok stupanj uporabe računala u jednostavne svrhe (npr. unos i obrada teksta i puštanje zvučnih zapisa), dok je uporaba računala u svrhu programiranja i izrade nastavnog softvera bila iznimno rijetka među nastavnicima.

Kao glavnu prepreku boljoj i/ili češćoj uporabi računala u poučavanju nastavnici su naveli sljedeće:

1. Nedostatak odgovarajuće opreme u školama – 36 (25,35%) sudionika
2. Neznanje uporabe računala ili odgovarajućeg softvera – 17 (11,97%) sudionika
3. Negativan stav prema uporabi računala u procesu poučavanja – 11 (7,75%) sudionika.

Zamjetno je da su navedene prepreke u skladu s čimbenicima koji su ustanovljeni u drugim istraživanjima (Sime & Priestley, 2005; Starkey, 2010).

Dosljedno gore navedenim smetnjama, načini za unapređenje uporabe računala u nastavi, prema mišljenjima ispitanih nastavnika, su sljedeći:

1. Bolja tehnička opremljenost škola – 84 (59,15)% sudionika
2. Kontinuirano obrazovanje nastavnika – 75 (52,82%) sudionika
3. Više dostupnog softvera – 50 (35,21%) sudionika
4. Više pomoći od nadležnih državnih službi – 34 (23,94%) sudionika.

Naše je mišljenje da bi se značajna poboljšanja (kvalitetom i kvantitetom), a koristeći postojeću razinu opremljenosti škola, mogla postići inzistiranjem na kontinuiranom obrazovanju nastavnika. To je vjerojatno najučinkovitiji način uzimajući u obzir da daje dobre rezultate u kratkom vremenu, koristeći skromnu materijalnu potporu.

Na kraju ovog dijela bit će predstavljeni rezultati statističke analize prikupljenih podataka u svrhu provjere vrijednosti hipoteza iznesenih u uvodu. Zaključeno je sljedeće:

2×2 analiza tablice kontigencije provedena je da bi se utvrdilo postoji li veza između uporabe računala u nastavnom procesu i vrste škole. Hi-kvadrat test s Yatesovom korekcijom nije pokazao značajniju vezu između uporabe računala i vrste škole, $\chi^2(1, n=142)=0.000$, $p=1.000>0.05$ (vidi također Sliku 4). Ovo je bilo očekivano s obzirom da nastavnici matematike u osnovnoj i srednjoj školi imaju jednaku naobrazbu.

Slika 4.

Mann-Whitney U test ukazuje da postoji značajna razlika između prosječnog radnog iskustva u populaciji nastavnika koji koriste (Md=15, n=126) i koji ne koriste računala u nastavnom procesu (Md=23, n=15), $Z=-2.275$, $p=0.023<0.05$ (vidi Sliku 5), potvrđujući našu hipotezu da računala češće koriste mlađi nastavnici (Md je skraćenica za medijanu).

Slika 5.

Slika 6.

Provedeni Mann-Whitney U test sugerira da ne postoji značajna razlika između prosječnog trajanja kontinuiranog obrazovanja u populaciji nastavnika koji koriste (Md=100, n=111) i onih koji ne koriste računala (Md=72, n=13) u nastavnom procesu $Z=-0.896$, $p=0.37>0.05$ (vidi Sliku 6). Kako god, važno je primijetiti da svi ispitanici koji su proveli značajan broj sati u kontinuiranom obrazovanju (više od 120) koriste računala u nastavnom procesu, što je donekle na tragu rezultata prethodnih istraživanja koja su ustanovila da je stručno usavršavanje iznimno važno za uspješnu implementaciju i uporabu računala u nastavnom procesu (Sadik, 2006; Yildirim 2000).

Nastavnici početnici

Drugo je istraživanje obuhvatilo 123 nastavnika matematike, početnika – pristupnika polaganju državnog stručnog ispita. Od ukupnog broja 80 (65,00%) ih je bilo iz osnovnih škola, a 43 (35,00%) iz srednjih škola. S obzirom na to da je Državno povjerenstvo jedinstveno za sve, imali smo ispitanike koji su diplomirali na različitim sveučilištima (66 diplomanata Sveučilišta u Beogradu, 17 sa Sveučilišta u Novom Sadu, 19 sa Sveučilišta u Nišu, 16 sa Sveučilišta u Kragujevcu i 5 diplomanata nekog drugog sveučilišta) i koji rade u različitim dijelovima Srbije (39 u Beogradu, 23 u Vojvodini, 30 u središnjoj i zapadnoj Srbiji i 31 u južnoj i istočnoj Srbiji). Stoga uzorak na odgovarajući način predstavlja stanje matematičkog obrazovanja u Srbiji.

Bitno je naglasiti da su nastavnici početnici doista početnici u nastavničkoj profesiji (neki od njih su prethodno radili na nekom drugom radnom mjestu). Uvjet pristupanju Državnom stručnom ispitu je jedna godina radnog iskustva na mjestu nastavnika matematike. Podatci o starosti pristupnika su prikazani na Slici 7, prosjek je 34,73 (±5,73), a srednja vrijednost (medijana) je 34,00.

Provedeno istraživanje se odnosi na dio stručnog ispita, točnije na sat matematike koji pristupnik održi u školi. U istraživanju smo se usredotočili isključivo na postignutu razinu izvedbe pripremljenog nastavnog plana (pri tome zanemarujući kakvoću same priprave). S obzirom na to da je to najvažniji dio samog stručnog ispita, prirodno je očekivati da izvedba nastavnog sata ne će biti lošija od nastave koju taj nastavnik inače izvodi svakog dana. Kakvoću izvedbe smo vrjednovali prema trima kategorijama: nezadovoljavajuće, zadovoljavajuće i dobro.

Slika 7.

Iz prikupljenih podataka ustanovili smo da 8 (6,50%) ispitanika nije uopće rabilo računala (njihova priprava je pisana rukom). Ocjene, temeljem našeg mišljenja, za 115 ispitanika koji su rabili računalo za obradu teksta prilikom pisanja priprave dane su u Tablici 2.

Među promatranom populacijom imali smo 60 nastavnika koji su imali grafičke prikaze u svojim nastavnim pripravama, no 17 ih je grafičke prikaze risalo rukom. Ocjene za ostale ispitanike dane su u Tablici 3. Također, ocijene za unos matematičkih formula dane su u Tablici 4 (2 su ispitanika formule pisali rukom).

Tablica 2. – 4.

Željeli smo provjeriti postoji li ikakva veza između, s jedne strane, sveučilišta na kojem su pristupnici diplomirali (u obzir smo uzeli samo četiri glavna državna sveučilišta), regije u kojoj rade, vrste škole gdje održavaju nastavu, prosjek ocjena tijekom studija, trajanje studiranja i, s druge strane, svojstava njihove nastavne priprave koju smo evaluirali. Temeljem statističke analize prikupljenih podataka dobili smo rezultate koje prikazujemo u nastavku.

S obzirom na vezu između uporabe računala u nastavnom procesu i sveučilišta na kojem je pristupnik diplomirao dobili smo rezultate predstavljene u Tablici 5. Provedena je A 4×3 analiza tablice kontigencije da bi se ustanovilo postoji li veza između uporabe računala (ocjene 1, 2, i 3) za obradu teksta i sveučilišta na kojem je kandidat diplomirao. Hi-kvadrat test nije pokazao značajnu vezu između uporabe računala i sveučilišta, Pearson Hi-kvadrat vrijednost (6, 110)=6,374, $p=0,383>0,05$. S obzirom na to da tablice kontigencije u ostalim slučajevima sadrže previše ćelija koji imaju vrijednosti manje od 5, Hi-kvadrat test nije mogao biti proveden. No prema Tablici 5, izgleda da sveučilište koje je ispitanik pohađao ne igra značajnu ulogu u kakvoći crtanja grafičkih prikaza ili unosu matematičkih formula.

Tablica 5.

Tablica 6.

Tablica 6 prikazuje ocjene za vrjednovana svojstva s obzirom na regiju u Srbiji. Provedena je 4×3 analiza kontigencije tablice da bi se ustanovilo postoji li veza između kakvoće obrade teksta kao i kakvoće unosa matematičkih formula i regije u kojoj nastavnik-početnik radi. Hi-kvadrat test pokazuje da su obje vrijednosti neovisne o regiji Srbije u kojoj nastavnik početnik radi:

- Pearsonova Hi-kvadrat vrijednost (6, 114)=8,995, $p=0,174>0,05$ (obrada teksta);
- Pearsonova Hi-kvadrat vrijednost (6, 112)=4,174, $p=0,653>0,05$ (unos formula).

Za grafičke prikaze Hi-kvadrat test nije mogao biti proveden. Unatoč tomu, izgleda da, kao i u prethodnom slučaju, među regijama ne postoji značajna razlika.

Tablica 7.

Provedena je 2×3 analiza tablice kontigencije da bismo utvrdili postoji li veza između kakvoće obrade teksta i unosa matematičkih formula te vrste škole u kojoj nastavnik radi. Kakvoća obrade teksta je neovisna o vrsti škole, vrijednost Pearson Hi-kvadrata (2, 115)=0,362, $p=0,834>0,05$. No postoji veza između kakvoće unosa matematičkih formula i vrste škole u kojoj nastavnik radi, vrijednost Pearson Hi-kvadrata (2, 113)=7,434, $p=0,024<0,05$. Situacija u srednjim školama je bolja od situacije u osnovnim školama (vidi Sliku 8).

Kod grafičkih prikaza Hi-kvadrat test nije mogao biti proveden.

Slika 8.

Prikazani podatci i analize govore u prilog našem prethodno spomenutom mišljenju da je situacija nezadovoljavajuća i uglavnom jednaka u svim školama diljem Srbije.

Proveli smo Kruskal-Wallis testove da bismo provjerili postoje li značajne razlike u prosjeku ocjena tijekom studiranja za promatranu populaciju (s različito vrjednovanim svojstvima).

- Postoje značajne razlike u prosjeku ocjena tijekom studiranja među populacijama nastavnika početnika koji su svoju nastavnu pripravu pisali rukom (Md=7,92, n=8), čija je računalna obrada teksta bila nezadovoljavajuća (Md=7,35, n=10), zadovoljavajuća (Md=7,52, n=52) ili dobra (Md=7,95, n=52), $\chi^2(3, n=122)=14{,}762$, $p=0{,}002<0{,}05$. Preciznije, po Mann-Whitney U testovima, postoji značajna razlika između populacije čija je obrada teksta nezadovoljavajuća i populacije čija je obrada teksta dobra ($Z=-2{,}422$, $p=0{,}015<0{,}05$), kao i između populacija čija je obrada teksta zadovoljavajuća i onih čija je obrada teksta dobra ($Z=-3{,}502$, $p=0{,}000<0{,}05$), vidi Sliku 9.
- Postoji značajna razlika u prosjeku ocjena tijekom studiranja među populacijama koje grafičke prikaze crtaju rukom (Md=7,84, n=17), za to rabe računalo nezadovoljavajuće (Md=7,35, n=21), zadovoljavajuće (Md=7,91, n=16) ili dobro (Md=8,14, n=6), $\chi^2(3, n=60)=10{,}333$, $p=0{,}016<0{,}05$. Preciznije, uporabom Mann-Whitney U testova, postoji značajna razlika između populacija čiji grafički prikazi su crtani rukom i onih koji su za to rabili računala na nezadovoljavajući način ($Z=-2{,}144$, $p=0{,}031<0{,}05$), kao i između populacija koje su za to koristile računalo na nezadovoljavajući i zadovoljavajuću način ($Z=-2{,}055$, $p=0{,}04<0{,}05$), i populacija koje su se računalom koristile na nezadovoljavajući i koje su se njime koristile na dobar način ($Z=-2{,}655$, $p=0{,}005<0{,}05$), vidi Sliku 10.
- Postoji značajna razlika u prosjeku ocjena tijekom studiranja među populacijama onih koji su unosili matematičke formule ručno (Md=7,39, n=2), za to su rabili računala na nezadovoljavajući (Md=7,58, n=50), zadovoljavajući (Md=7,80, n=32) ili dobar način (Md=9,12, n=30), $\chi^2(3, n=114)=10.358$, $p=0.016<0.05$. Preciznije, uporabom Mann-Whitney U testova, postoji značajna razlika između populacija koje rabe računala za unos formula na nezadovoljavajući način i na dobar način ($Z=-2{,}922$, $p=0{,}003<0{,}05$), vidi Sliku 11.

Slika 9. – 12.

S obzirom na dužinu studiranja sudionika naše studije, dobiveni su sljedeći rezultati:

- Provedeni Kruskal-Wallis test, $\chi^2(3, n=118)=2{,}648$, $p=0{,}449>0{,}05$, ne sugerira da postoji statistički značajna razlika između dužine studiranja i onih koji su tekst pisali rukom (Md=7,50, n=8) ili onih čija je obrada teksta nezadovoljavajuća

(Md=10,00, n=9), zadovoljavajuća (Md=8,00, n=51) ili dobra (Md=8,50, n=50), vidi Sliku 12.

- Provedena Analiza varijance (ANOVA) ne sugerira postojanje statistički značajnih razlika u dužini studiranja među ispitanicima koji su svoje grafičke prikaze crtali rukom (8,13±0,786, n=15), ili su za to rabili računalo nezadovoljavajuće (9,65±0,650, n=20), zadovoljavajuće (8,38±0,576, n=16) ili dobro (7.17±1.078, n=6), $F(3, 53)=1.675$, $p=0.183>0.05$, vidi Sliku 13.
- Provedeni Kruskal-Wallis test ($\chi^2(3, n=110)=1,544$, $p=0,672>0,05$) ne sugerira postojanje statistički značajnih razlika u dužini studiranja među populacijama ispitanika koje su matematičke formule pisale rukom (Md=9,50, n=2), ili su za to rabili računala nezadovoljavajuće (Md=8,50, n=48), zadovoljavajuće (Md=9,00, n=32) ili dobro (Md=8,00, n=30) (vidi Sliku 14).

Slika 13.

Slika 14.

Prikazani podatci i analize ukazuju da nastavnici s višim akademskim postignućima tijekom svog studiranja rabe računala na primjereniji način. Navedeno također sugerira da je studij najvažniji dio obrazovanja budućih nastavnika, kad je potrebno stvoriti čvrste temelje za pravilnu uporabu računala u nastavi. To moramo imati na umu prilikom razvoja kurikula i/ili sveučilišnih nastavnih programa. Lin (2008) također preporuča da program za izobrazbu nastavnika matematike bude recenziran uzimajući u obzir potrebe studenata i istovremeno pripremajući buduće nastavnike za učinkovitu uporabu tehnologije u poučavanju matematike.

Također, zanimljivo je primijetiti da nastavnici-početnici koji pišu tekst i crtaju grafičke prikaze rukom imaju bolji prosjek ocjena tijekom studija od onih koji u tu svrhu rabe računalo, ali na nezadovoljavajući način. Smatramo da je razlog tomu nedostatak pozitivnog stava prema uporabi digitalnih tehnologija u poučavanju.

Zaključak

U dvije neovisne studije istraživali smo uporabu računala u nastavnom procesu u Srbiji. Jedna se odnosila na iskusne nastavnike s položenim državnim stručnim ispitom, a druga na nastavnike-početnike, kandidate za polaganje državnog stručnog ispita. Željeli smo utvrditi razinu uporabe računala, trenutnu situaciju i razloge koji se kriju iza toga te načine kako povećati i poboljšati uporabu računala.

Prvi važan rezultat našeg istraživanja je da je razlika između uporabe računala za osobnu i poslovnu uporabu prevelika te da razina uporabe za osobne potrebe pruža mogućnost za brzo uvećanje uporabe računala u nastavnom procesu. Smatramo da su uzroci takvim razlikama sljedeći: (1) s nastavničkog stajališta poučavanje uz pomoć računala je vrsta inovacije koja donosi i određene probleme (Henry, & Clements, 1999); (2) uloga nastavnika više ne bi trebala biti samo klasičan predavač (Hsu, Wu,

& Hwang, 2007). Zbog toga se nastavnici ne protive uporabi digitalnih tehnologija generalno, ali je očito da nisu potpuno sigurni u načine njihove implementacije u nastavni proces.

Kao što se moglo očekivati, mlađi nastavnici prednjače u uporabi računala u nastavi. Uz to, istraživanje pokazuje da na uporabu računala u nastavi glavni utjecaj proizlazi iz prosjeka ocjena tijekom studiranja i njihova ustrajnog kontinuiranog obrazovanja. Može se primijetiti da razina kakvoće uporabe računala ne ovisi o sveučilištu na kojem je nastavnik stekao diplomu ni o tomu gdje radi (neovisno gledamo li tip škole ili ekonomsku razvijenost regije u kojoj se škola nalazi).

Prikupljeni rezultati su nas još više uvjerili da je obrazovanje nastavnika strateški kritičan period tijekom kojeg je nužno učiniti poboljšanja, primjerice učinkovitu integraciju računala u kurikul. Učiti poučavati matematiku uporabom tehnologije najučinkovitije je kad je tehnologija integrirana u kurikul obrazovanja nastavnika (Baki, 2000). Studenti s pozitivnim stav*om prema matematičkim računalnim alatima su nadišli početne poteškoće prilikom uporabe* tih alata i postali su učinkovitiji (Pierce, & Stacey, 2004; Reed, Drijvers, & Kirschner, 2010). Tijekom njihova obrazovanja (temeljnog i kontinuiranog) nastavnike je potrebno ohrabrivati da razviju ispravan stav i postanu kvalificirani za uporabu novorazvijenih digitalnih alata za poučavanje. Pojam *biti kvalificiran* podrazumijeva ne samo pružanje mogućnosti nastavnicima da steknu znanja o novim tehnologijama, već i da nauče kada i kako upotrijebiti dostupnu tehnologiju (steći vještinu). Moguće rješenje vidimo u pružanju šireg raspona tema izravno vezanih na školsku praksu u didaktičkim kolegijima na nastavničkim fakultetima, što bi pomoglo budućim učiteljima-nastavnicima u rješavanju mnogostrukih problema koje mogu susresti u praksi. Također predlažemo restrukturiranje postojećih kolegija na način da potiču uporabu digitalnih tehnologija koje mogu pridonijeti kakvoći nastavnog procesa.

Prije nekoliko godina, na nekim sveučilištima u Srbiji, u matematički kurikul je uveden kolegij nazvan Edukacijski softver. Namjera kolegija je bila povećati zanimanje za softverske pakete, posebice CAS-IG alate, kao i razviti pozitivne stavove prema uporabi suvremenih tehnologija u poučavanju. Studentima su prikazani primjeri dijelova matematičkog gradiva gdje bi se u poučavanju mogao primijeniti odgovarajući softverski paket. Ta odluka će, prema našem mišljenju, najviše utjecati na buduće nastavnike, studente koji će tek diplomirati u godinama koje su pred nama; oni će utjecati na promjenu stava prema uporabi digitalnih tehnologija u nastavnom procesu. Ozbiljno istraživanje, koje bi pratilo naše diplomce kroz duži vremenski period, ako govorimo o njihovom radu, moglo bi dati preciznije odgovore na postavljena pitanja.

Napomena

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