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Empowering Teachers' Digital Competence Through the Implementation of the "Digital Classroom" Project

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Abstract: *In a Knowledge Society, the kind we aspire to today, the education system becomes the pillar and the initiator of general progress in society, while knowledge is perceived as the most important human resource and capital. The inevitable changes in the education system are primarily reflected in the change of necessary competencies of teachers. Acquiring digital competence by way of applying information technologies in the teaching process becomes a prerequisite in professional development of teachers. In this paper we shall consider the basic training concept and the main results of the evaluation of the "Digital Classroom" project, implemented by the Institute for the Improvement of Education with the objective of empowering digital competence of teachers. The assessment of the increase in teacher competence was carried out using the pretest-posttest concept where 80% of teachers who completed the training had greater achievements than the average achievements of teachers before the training. The effects of the training become noticeable in all aspects measured on a sample of teachers.*

Keywords: *ICT; teacher's professional development; digital classroom; teachers' digital competence*

1. INTRODUCTION

The significance of information and communication technologies (ICT) in all aspects of society today is the standard for development in the global information society. In recent years, the government of the Republic of Serbia has implemented a number of strategic documents as a set of guidelines for informatization of the education system.

The institutional, as well as the legal framework are provided at first implementing the Guidelines for Improving the Role of Information and Communication Technologies in Education brought by the National Education Council of the Republic of Serbia in 2013 [1], while the Ministry of Education, Science and Technological Development of the Republic of Serbia, in partnership with the British Council, published the Digital Competence Framework – A Teacher for the Digital Age in 2017 [2]. The Framework was completely revised in 2019 in a joint effort by the Institute for the Improvement of Education, the Ministry and the Institute for Education Quality and Evaluation.

One of the most important projects under the auspices of this kind of Government Strategy, carried out by the Institute for the Improvement of Education, in collaboration with the Ministry of Education, Science and Technological Development, is the project called Digital Classroom/Digitally Competent Teacher – Introducing Electronic Textbooks and Digital Educational Materials which is included in the Plan of Priority Objectives and Activities of All State Administration Bodies and Government Services for IT Sector Improvement in Serbia for 2018 and is ranked fourth on the priority list consisting of nineteen priority projects [3].

2. THE OBJECTIVES OF THE "DIGITAL CLASSROOM/DIGITALLY COMPETENT TEACHER" TRAINING

At a conference on 8th January 2008 a document named ICT Competency Standards for Teachers (UNESCO, 2008) was presented, introducing guidelines for skills standards for teachers that are to be accomplished through professional development. At the same time, professional development of teachers through use of information and communication technologies is recognized through three main approaches [4]:

- Technology Literacy,
- Knowledge Deepening and
- Knowledge Creation.

The main objective of this project is contributing to the development of digital competences which are defined as the set of knowledge, skills, attitudes, abilities and strategies that are required when using information communication technologies and

digital media, with the purpose of improving teaching and learning processes and other activities in connection with the teaching profession reflectively, flexibly and safely in both online and offline environments (Ferrari, 2012).

The objectives of the training for trainers/teachers included acquiring digital competence, providing information and communication structure in schools, as well as teaching practice and professional development of teachers and are defined as:

- Acquiring and developing a level of digital competence for teachers in order to enable work with information and communication technologies;
- Training teacher mentors for further training of participants based on the „train-the-trainer" model, including acquiring soft skills;
- Training teachers to be able to prepare, adjust and use digital educational materials;
- Practically applying digital textbooks in the teaching process, thus providing the teacher with opportunities to realize teaching in a modern way with integration of teaching content;
- Introducing teachers to and training them for work on contemporary tools for learning management systems – LMS platforms;
- Encouraging teachers to create cognitively stimulating activities intended for pupils in a digital environment.

The top priority of the programme's development plan is:

P1 – Developing digital competence in both pupils and teachers and using information and communication technologies in the educational process.

The training programme was created according to the outcome-based approach to learning and teaching and is directed towards developing the following areas of competence in both teachers and students:

(K1) competency for a narrow area of expertise

(K2) competency for teaching and learning

3. THE "2000 DIGITAL CLASSROOMS" PILOT PROJECT

The project was carried out during 2018 as a pilot project named "2000 Digital Classrooms".

In phase one of the project 98 teacher trainers were trained, and among them a number of trainers were selected and they received certificates for further training and giving support to a group of selected teachers. All of the chosen certified teacher trainers were obliged to provide mentoring assistance to teachers working with digital educational materials and digital textbooks.

The training participants were 2000 first grade (Serbian, math, science and social studies, art, music and foreign languages) and fifth grade teachers (Serbian language and literature, math, history, geography, biology, informatics and computer science, technics and technology studies, art, music and foreign languages) working in primary schools educated to actively use modern technology and modernly designed e-textbooks in their work.

The teachers chosen by their schools to be trained for the programme, received adequate equipment, digital materials and teacher trainer support.

3.1. The training concept

The teacher training was devised as a three-day course divided into modules in accordance with the objectives of the training.

1. Support in acquiring digital competence in areas of:
   - Handling computer equipment;
   - Using the principles of constructivism for the purpose of applying technology in teaching – teaching then and now;
   - Opening, accessing and managing accounts on the digital educational resources' portal;
   - Functionality of educational portals intended for realization of teaching in a digital environment;
   - Using the Internet, e-mails and cloud services safely.
2. The practical application of digital textbooks in teaching:
   - Digital educational content – digital textbooks (Using integrated textbook sets);
   - Contemporary tools for distance learning LMS - Learning Management System.
3. Lesson planning

The task for the teachers was to plan a lesson on their own in form of a presentation. The best lesson plans were added to the Lesson Database which can be found on the official website of the training programme www.digitalnaucionica.edu.rs and is available to all the employees working in education system.

3.2. Handling computer equipment

This segment of the training focused on introducing teachers to the components of the computer system; connecting basic computer parts to peripheral devices; setting the image display mode on the computer screen and the projector and computer networking.

Each trainer/teacher got acquainted in detail with the union of hardware and software, the connection between the computer and peripheral devices, and also with working in an operating system and connecting the computer to a local network.

The teachers were given equipment which consisted of a computer, a projector, an Internet connection and required peripheral devices. One of the outcomes for this segment was to train every teacher to use the provided equipment with the purpose of presenting other content and materials from the training.

3.3. The constructivist approach to teaching

Constructivism as a theoretical concept was presented in training, a concept that insists on the fact that knowledge building is based on individual experience and that knowledge as such is unique to each individual. New terms introduced into the context of educational policy are "lifelong learning" and "knowledge society".

The main characteristics of school based on constructivist principles are: knowledge is acquired by being actively introduced to new content, the students are responsible for their learning, learning develops the culture of learning thus providing a broader autonomy to learners.

3.4. Opening, accessing and managing accounts on the digital education resources portal

Based on the public notice issued by the Ministry of Education, Science and Technological Development, a large number of textbook and teaching resource publishers sent their digital materials to the Institute for the Improvement of Education in order to be accredited, and subsequently, the Institute gave permission for the use of digital educational resource portals.

Teachers were able to create their own accounts on the portals of their chosen publisher and use the portals in teaching.

Educational portals such as these provided the teachers with the following:

- Using digital textbooks;
- Establishing contact directly through the portal (access to one's own school, other teachers – colleagues, school classes and pupils);
- Having direct communication with pupils (internal e-mail system, discussion forums, chat rooms…);
- Assignments/tasks, tests, exercises, homework (tools for creating such modules or access to the assignments);
- Monitoring progress – pupil progress statistics (reports on individual pupils or whole classes).

3.5. Using the Internet, e-mail and "cloud" services safely

The teachers got to know the rules for safe use of Internet browsers, as well as how to independently communicate with other participants via e-mail using free providers and also, how to use "cloud" services.

In order to facilitate adoption of this training segment, the teachers were obliged to open email accounts through free providers, choosing the parameters based on the recommendations from the training.

Special attention was directed towards Internet ethics, copyrights and types of licenses. In a number of workshops, the teachers received assignments on specific topics with the task of finding contents relevant to the topics on the Internet first, then safely downloading it and finally using it to create their own presentations. While doing this they had to pay attention to copyrights, properly citing their sources and licenses.

3.6. Digital education and digital educational content

This segment of the training emphasized the main characteristics of digital textbooks – they are based on multimedia and hypertext, therefore, they are not linear, but rather, their contents branch in various directions.

Within workshop activities, the teachers were given an assignment to examine digital textbooks from various publishers and determine the kind of digital textbook, as well as its main features. The next step required that the teachers, based on the established criteria, choose the digital textbook that is best suited for the subject their teach.

3.7. Contemporary tools for distance learning LMS - Learning Management System

As a unified software system that enables virtual, collaborative environment for the complete teaching process, the Learning Management System, LMS was presented to the teachers.

The advantages of the blended learning/hybrid learning which combines face-to-face teaching with computer-assisted teaching, mixing the use of contemporary digital media with the traditional and well-established teaching techniques were presented.

The teachers were not given explanations on the technical characteristics of such systems, they were introduced to the pedagogical aspects of it, with emphases on the ease and speed of communication with pupils.

4. ASSESSMENT OF THE TRAINING EFFECTS ON TEACHERS

The assessment of the increase in teacher competence was carried out using the pretest-posttest concept without forming a control group. Teachers were not randomly sampled, questionnaires were distributed to all the teachers who had completed the training (1920 teachers) and they were first questioned immediately before

the training began. Three months after the training, electronic questionnaires were sent to e-mails of all the teachers who were already tested before the training. A total of 1407 teachers completed the questionnaire.

The instrument for assessment of the effects of teacher training consisted of four parts.

The first part was the knowledge test. The test was created with the purpose of evaluating the level of teachers' digital competence before and after the training.

The knowledge test included twenty multiple choice questions with one or more correct answers, covering 11 areas that were presented in the training, so that the following areas are included with at least two questions: Operating computer equipment; Principles of constructivism for the purpose of applying technology in teaching – teaching then and now; The use of the Internet, e-mail and "cloud" services; Opening, accessing and managing accounts on the digital educational resources portal; Functionalities of the learning management system intended for the realization of the teaching process in the digital environment; Digital educational content - digital textbooks; Use of a unified textbook set - practical application; Use and creation of additional materials / tests; Modern tools of the learning management system (LMS, Learning Management System); Advantages and problems in the use of modern tools (LMS); Working in a digital classroom.

The second part of the instrument consisted of teachers' self-assessments in relation to the practices associated with digital and online learning. This part of the instrument gathers information from teachers using a five-level Likert-type scale [6], about how often they practice certain digital and online learning activities in their teaching. This part of the instrument consists of 12 items which refer to how often do the teachers create digital materials for teaching and learning and whether they are adjusted to the pupils' needs, how often do they use digital technologies in assessing pupils' achievements, how often they motivate students to get involved in various digital environments that encourage learning (networks, collaborative services, repositories), etc.

The third part of the instrument consisted of self-assessment of teachers' digital competence. This part includes 21 items, the teachers are asked to evaluate, on a five-level Likert scale, the degree to which they agree with the claims about different levels of development of digital competence. The claims were based on the Digital Competence Framework – A Teacher for the Digital Age, which was adopted by the Ministry of Education, Science and Technological Development in 2017. [2]

The fourth part of the instrument served to gather information on digital infrastructure that exists in schools. These data were not directly under evaluation, however, they do represent a relevant source for the evaluation, given the fact that adequate infrastructural conditions are a necessity for a successful application of digital and online learning in regular school classes, which is the main objective of the training.

4.1. Estimates of changes in teaching practices on a sample of pupils

Assessment of the growth of teacher competencies and perceptions, based on a sample of pupils, is being done according to the pretest-posttest concept, including a control group with multiple dependent variables. The choosing of pupils was conducted taking into account the criteria of geographic similarities with the experimental school, so as to minimize the influence of different variables from socio-cultural context.

The sample consisted of fifth grade pupils, since questioning first grade pupils by way of self-assessment tests would be impossible (the teachers attending the training were first grade and fifth grade teachers). All the claims were adjusted as much as possible in order to be age-appropriate for the pupils.

Electronic questionnaires were sent to nine experimental schools, and in each school a fifth grade class, taught by the teachers who finished training, was questioned, and in nine control schools as well, a fifth grade class was chosen from each school to complete the questionnaires, a total of 402 students. In the posttest phase, the same students answered the questionnaire, with 309 students from a total of 17 schools answering the questionnaire.

Equalizing between experimental and control group schools was conducted according to geographical criteria, thus controlling the influence of socio-cultural variables and the level of development of municipalities. Given the fact that there were fewer schools than teachers in the assessment, this kind of equalization was possible.

The instrument used to evaluate the effects of training through changes in teaching practice was directed towards measuring different perceptions of pupils, as someone who is completely unbiased to report on prospective changes in digital and online learning in teaching. The instrument consisted of two parts.

The first part of the instrument consisted of pupil evaluation of teachers' practice in relation to digital and online learning. This part of the instrument serves to gather data from the pupils via five-level Likert scale, on how often the teachers practice in school certain digital and online learning activities that include students. This part of the instrument consists of 11 items which question how often pupils use digital technologies in learning activities.

The second part of the instrument included self-assessment of pupils' digital competence. This part

of the instrument, much like the one for teachers, is based on the Digital Competence Framework – A Teacher for the Digital Age, however, with major adjustments, to be age-appropriate for the pupils.

For Data processing, the data were collected on the basis of the electronic platform Qualtrics, and were processed in the opensource programming language R.

4.2. Teacher progress on the ICT knowledge test

On the pretest, teachers scored an average of 11.28 correct answers out of possible 20 (σ=3,54; max=19; min=0). None of the teachers achieved the maximum number of points, and the distribution of teacher achievement according to the Shapiro-Wilks test does not deviate from the normal distribution (w = 0,98; p>0.05) [7].

After three months the teachers were given the same knowledge test. This was possible since there was no opportunity to make a parallel version of the test that would be equally difficult, and making it would require a piloting phase, and also, a lot of time passed between the two tests. In support of this decision is the fact that the pretest was difficult, and there was no fear of the ceiling effect, in other words, with a level of certainty we can claim that the same test can be able to detect teachers' progress.

The teachers scored on average 13,98 points on the posttest. Only six teachers achieved the maximum number of points on the knowledge test, which further indicates that the test was sensitive enough to register real progress of teachers and avoid the ceiling effect. This distribution deviates from normal distribution, which can be expected from a posttest, because the examinees were significantly more successful than doing the pretest. This distribution also does not deviate from the normal distribution (w = 0.94; p> 0.05).

On figures 1 and 2 the teachers' progress is shown graphically, first on a density function (the area under this function corresponds to the probability from 0 to 1 for the given value and then through a classic histogram showing the number of teachers in relation to the sum of correct answers on the knowledge test.

One of the important illustrations of how successful the training was and improved the ICT knowledge of teachers, tells us the decrease in the percentage of teachers with very low achievements.

On the pretest, 7.2 or less correct answers were given by 7.2% of teachers, while on the posttest, this percentage of teachers decreased to only 1% of teachers.

Given that this research was done on the entire population of teachers who are subject to evaluation of training effects, it makes sense to talk only about the intensity of the effects, but not about the statistical significance that tells us about the probability that the results obtained in the sample are credible for population. The magnitude of the effect is such that it can be considered as large (Cohen's d = 0.82) [8].

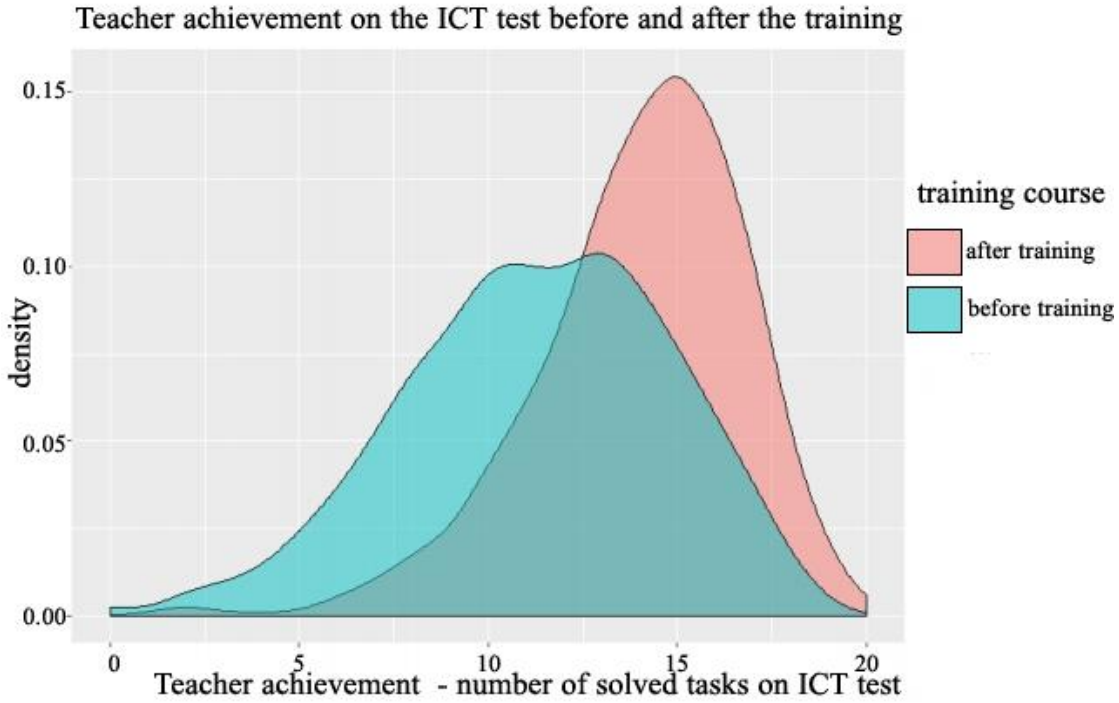

Figure 1. *Density function showing teachers' pretest and posttest achievement (*X axis - *achievements – the number of solved assignments on the ICT knowledge test;* Y-axis *– density)*

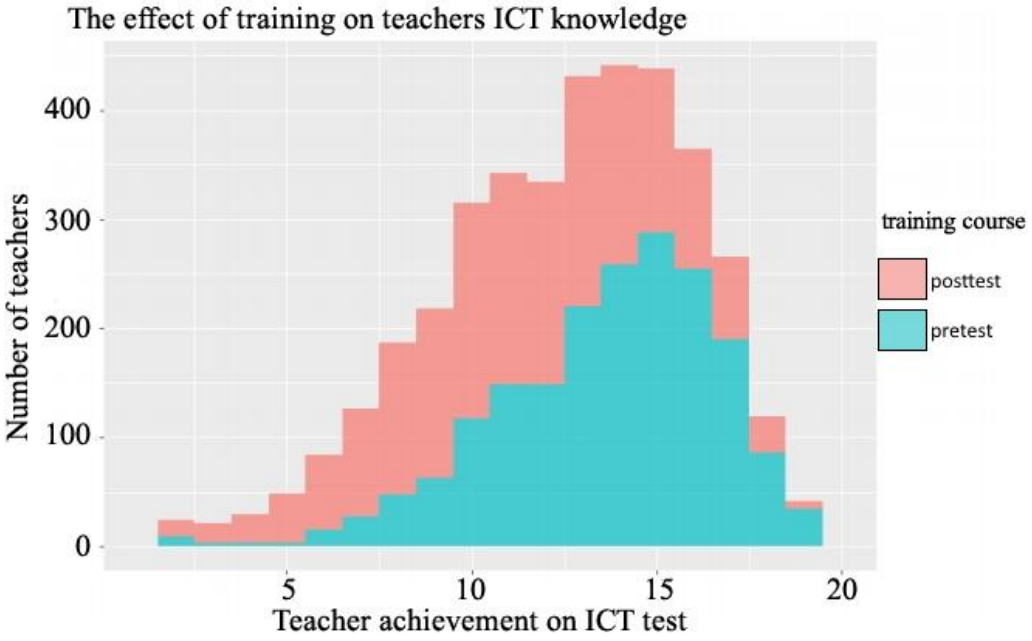

Figure 2. *Teachers' achievements before and after training – the number of teachers in comparison to the number of solved assignments (X-axis – ICT knowledge test achievements; Y-axis – The number of teachers)*

In conclusion, we can claim that 80% of teachers who completed the training had greater achievement than the average achievements of teachers on the pretest. If we were to randomly pick a teacher's knowledge test achievements before the training and the knowledge test achievements of a randomly selected teacher after training, in 71% of cases the after-training teacher would have greater achievements. Given the fact that various researches show that the effect of intervention is mostly lost after three months, these results indicate that such a strong effect of training can be accepted as lasting.

4.3. Changes to teachers' self-assessment practices related to digital and online learning

The teachers estimated that they started using digital and online learning in their classes to a greater extent after the training. Before training, the teachers estimated that on average, on a five level scale, they would use digital environment and materials once or twice per semester (M=3,33). After training, the teachers reported using this kind of practice once or twice a month, on average (M=3,66).

Taking into account all the digital and online learning practices, before training the teachers showed they were least likely to provide support for students in an online environment (once or twice per year), while using this environment most frequently to search for and download digital materials off the Internet for the purposes of teaching and learning (several times a week).

The greatest effect of training on changing teaching practices was the increase of sharing experiences and knowledge through digital environments for collaboration with other teachers, as well as greater use of existing digital technologies in teaching (portals, films, presentations, online tests, etc.).

During training, this segment showed the greatest difference in teacher experience. Also, teacher collaborations over various online services, as teachers claim, was the segment of training that was the most elaborate and it allowed them to easily adopt the experiences of their colleagues.

The minimum training effect was observed on encouraging pupils to use digital technologies in order to join learning communities outside school environment (using various portals, learning networks, forums, blogs). Also, a minimal effect was noticed when it comes to teachers downloading and searching digital contents on the Internet, since the teachers had been doing this to a great extent before the training.

The magnitude of the effect of changing teaching practices as a result of training varies from moderate to small, depending on the segment of training (from Cohen's d = 0.41 to d = 0.08). This means that 66% of teachers who completed training will have more developed digital and online learning practices then before training, and for those practices that had the strongest effect during training. If we were to randomly pick a report on digital practices of a teacher before and after training, in 61% of cases the teacher would have more developed digital practices after the training.

The extent of the effect of changes to teachers' perception of their own competence as a result of training varies from moderate to slight, depending on the digital skill in question (from Cohen's d = 0.46 to d = 0.02).

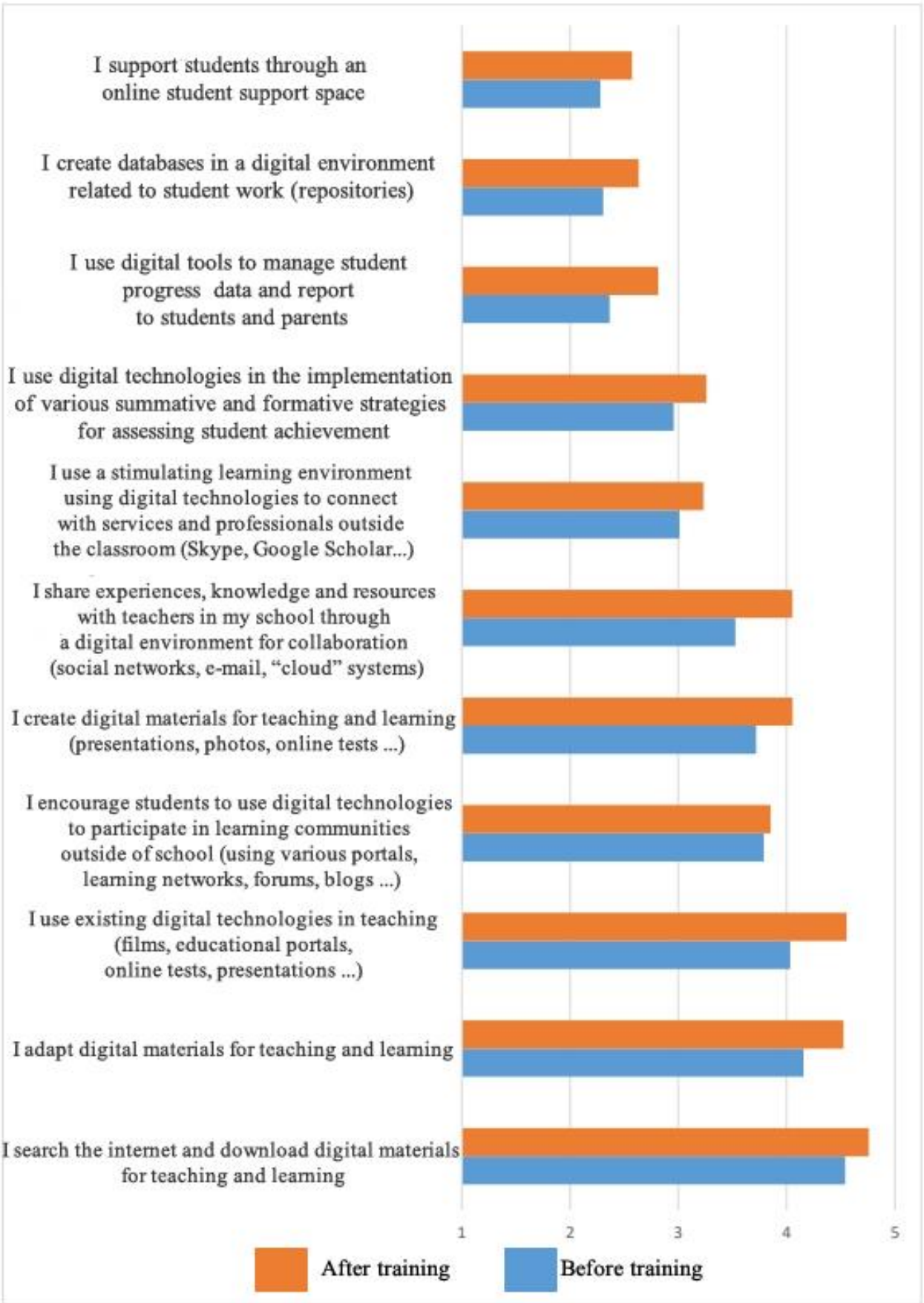

Figure 3. *Changes in teaching practice in regard/relation to digital and online learning*

4.4. Changes in teachers' self-assessment in connection to their own digital competence

The teachers have reported that they started to perceive themselves as significantly more digitally competent. Before training, on average, they would report that they agree to some extent or that they are not sure to what extent they could apply different skills and knowledge in relation to digital competence(M=3,83). After training, on average, the teachers report significantly higher self-confidence and agree to some extent or completely agree that they can implement different knowledge and skills in relation to digital competence (M=4,23).

Taking into account all of the digital skills tested, before training the teachers would estimate having the least knowledge on how to use digital tools for conference calls and collaborative "cloud" systems. What they estimated having greater knowledge of was searching the Internet and saving and finding information on the computer.

The greatest effect of training on teachers' perception of their own digital competence can be seen on teachers' use of collaborative "cloud" services and using these repositories when working with pupils. The least effect of training on perception of one's own competence has been noticed in those digital skills that the teachers had previously, before training, perceived as being most competent at (searching the Internet and storing information on the computer).

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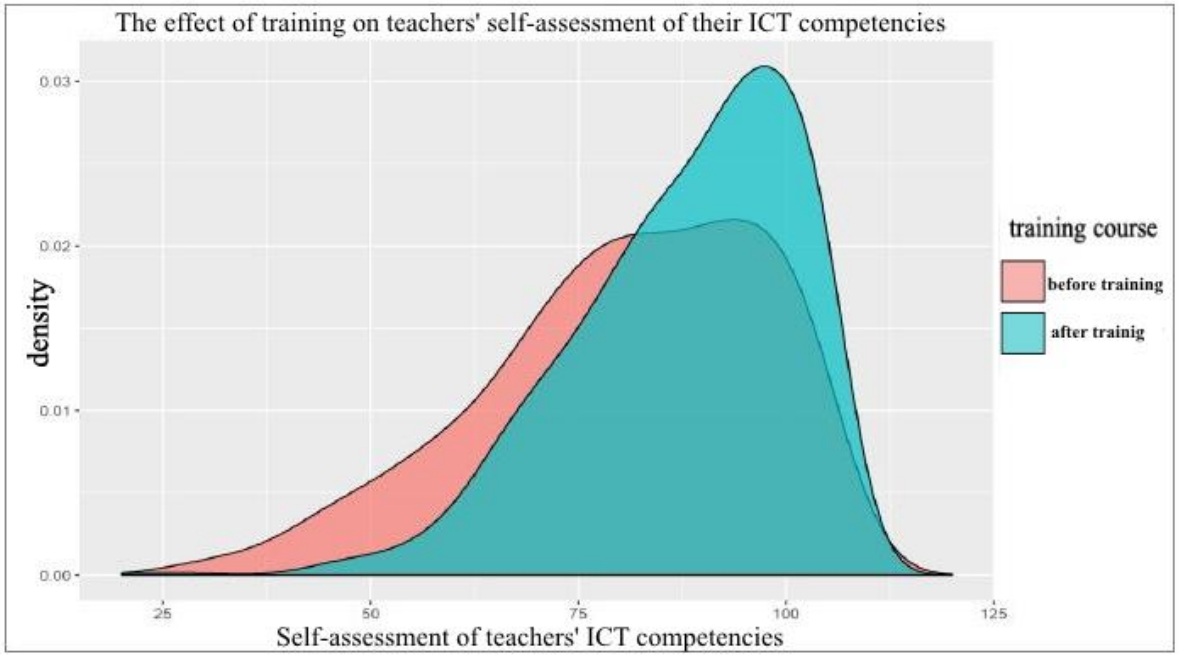

Figure 4. *Density function of self-assessment of teachers' ICT competencies before and after training*

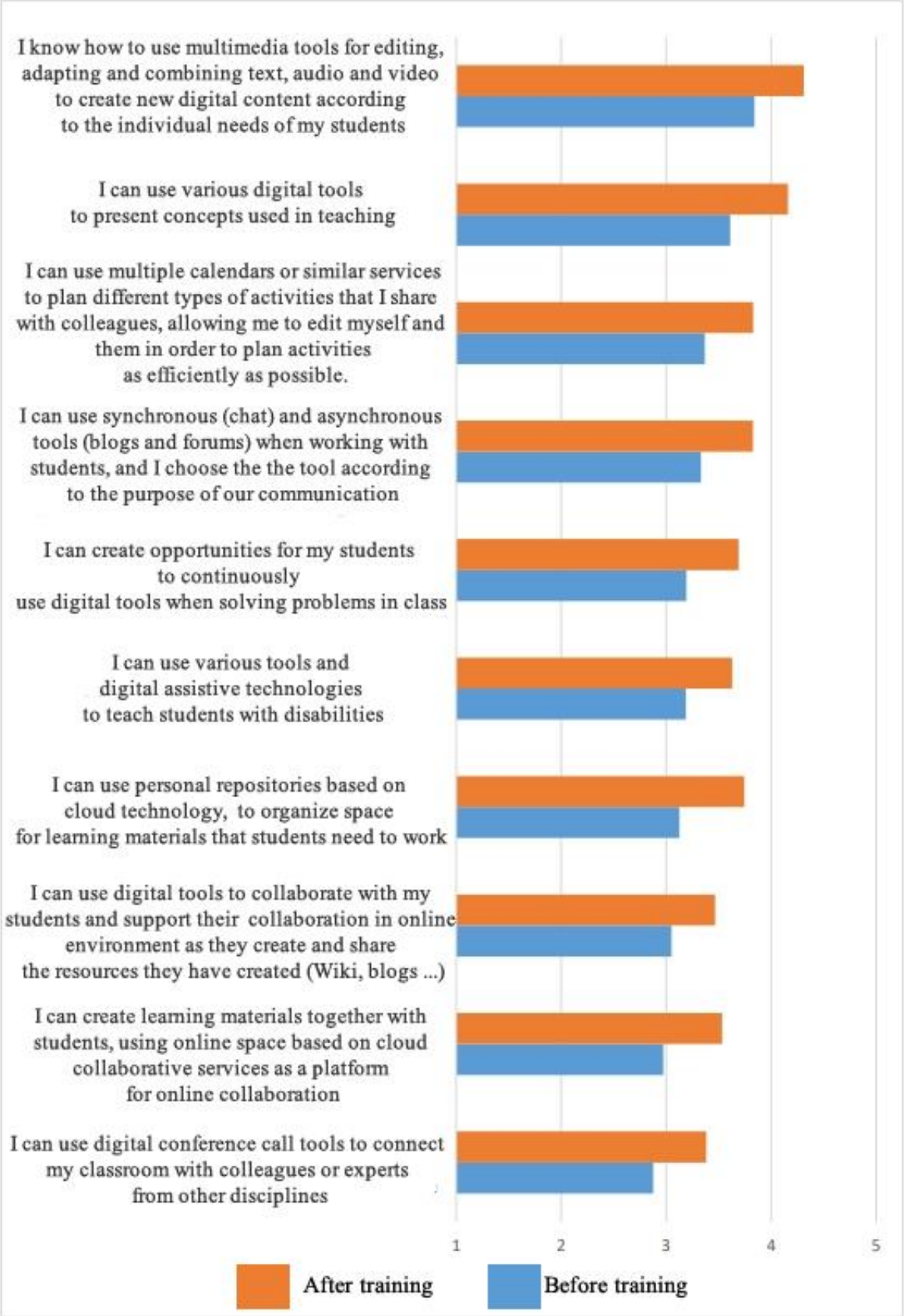

Figure 5. *Changes in teachers' self-assessment regarding their own digital competence 1*

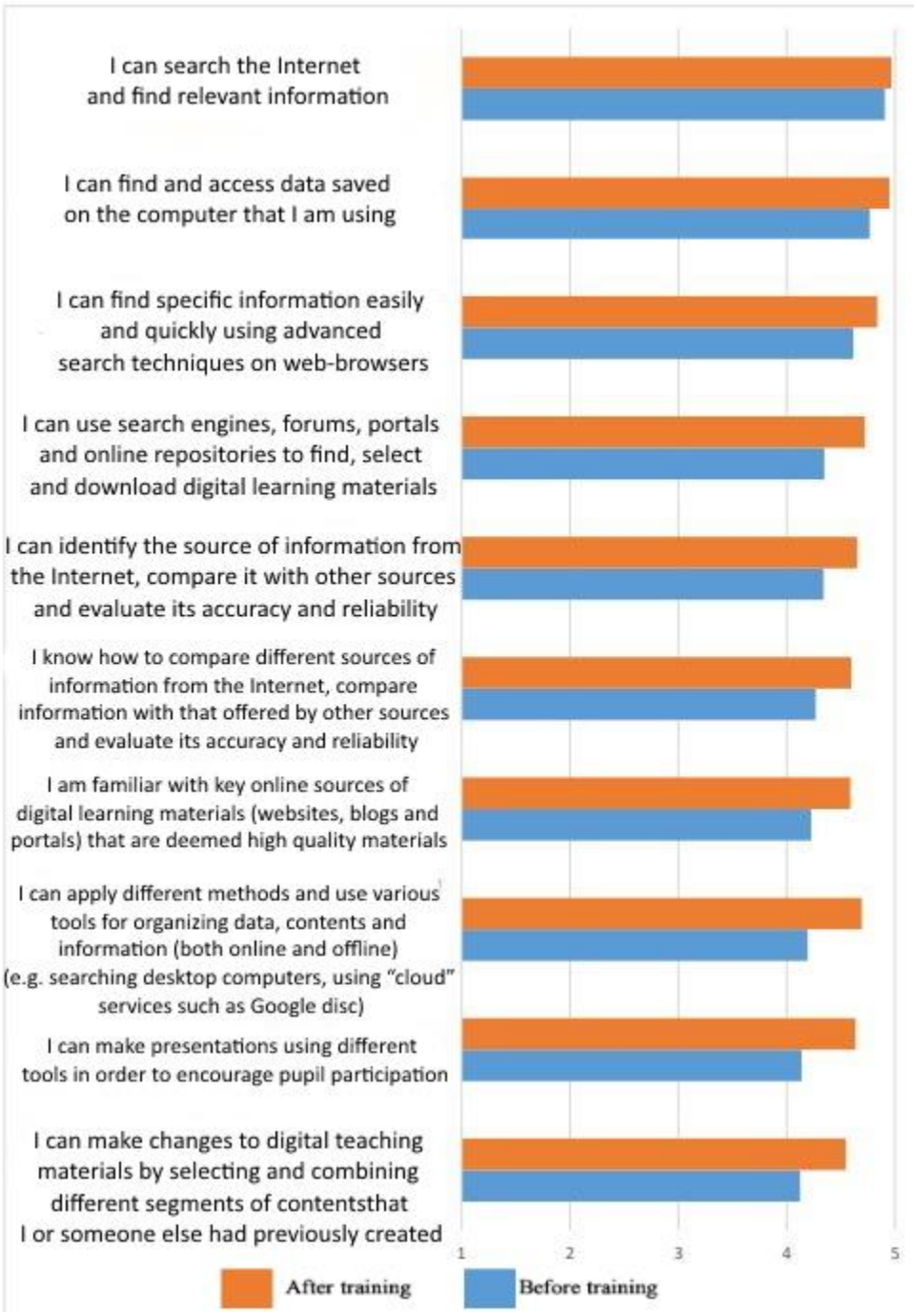

Figure 6. *Changes in teachers' self-assessment regarding their own digital competence 2*

4.4. Conclusion on the effects of training on teachers

The effects of the training are noticeable in all aspects measured on a sample of teachers. Teachers' perceptions have significantly changed after training. The teachers have reported that they use different acquired digital skills in teaching more often than before, that interaction with pupils occurs in digital environment to a much greater extent, and also, that they make greater use of various digital contents in teaching. The teachers also report that they feel much more confident in their digital competence, especially when it comes to skills they were least confident about before training, mostly having to do with using different digital environments for interaction and collaboration.

The most encouraging fact is that the training had great effects on teachers' understanding of various aspects of digital knowledge. If we take into consideration that perception, even though considered to be one of key methods of various psychological and pedagogical evaluations, is always susceptible to various bias, and especially self-perception, this growth of directly evaluated teachers' knowledge of digital content can indicate that the teachers, thanks to the conducted training, have been significantly empowered to successfully use digital and online learning practices in their teaching.

5. CONCLUSION

Over the course of three years of realizing the project "Digital classroom", the Institute for Improvement of Education has trained 20 000 teachers working in primary and secondary education in the Republic of Serbia. The most encouraging fact is that the training had great effects on teachers' understanding of various aspects of digital knowledge.

The plan of the Institute, in agreement with other educational policy makers, is to train all teaching staff working in pre-university education, as basic point in achieving complete informatization of the education system.

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