Personal e-Learning Environment of the Maths teacher' online course as a means of improving ICT competency of a Mathematics teacher

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Abstract. The paper studies the issue of increasing the ICT competency of a Maths teacher. The study analyzes the concept of ICT competency of a Maths teacher and considers the possibilities of its formation in different countries. One of the ways to increase the ICT competency of a Maths teacher is to use the "Personal e-learning environment of the Maths teacher" online course. The authors describe the model of the developed course, which is based on the ADDIE model and takes into consideration the key activities of a teacher. The experiment, conducted among master's students majoring in "Secondary education. Mathematics" showed the positive effects of the developed course on the level of their ICT competency. The redistribution of the percentage of the students towards normative and high levels of ICT competency formation was observed.

1. Introduction

1.1. Problem statement and its topicality substantiation

In the current circumstances of the global spread of distance learning, the problem of teachers' awareness of various information and communication tools is increasingly growing in importance. Their use by a present-day teacher is closely related to the selection of Web-tools for creating their own Personal Learning Environments (PLE), which provides a variety of activities. Thus, a Maths teacher, in particular, should not only organize students' learning activities but also search for information, conduct research, analyze and statistically process information, perform calculations, publish research findings, present reports and lectures, collaborate with other colleagues, and more. All this entails the need to constantly train teachers and form their ICT competency.

1.2. Analysis of the latest research and publications

Several studies have been devoted to addressing certain issues of the problem of Maths teachers' ICT competency (UNESCO [1], Kaiser and König [2], Jusoh et al. [3], Cetinkaya, Erbas, Celikdemiret al. [4]).

Thus, the United Nations Educational, Scientific and Cultural Organization (UNESCO) in partnership with leading industry organizations and experts from different countries developed "ICT Competency Framework for Teacherss" recommendations [1]. They include 18 competencies that are structured in accordance with six aspects of professional teaching activities (understanding the role of ICT in education policy, curriculum and assessment, teaching practices, application of digital skills, organization and management of the educational process, professional development of teachers) and three levels of applying ICT for teaching purposes (acquisition of knowledge, advancement of knowledge and construction of knowledge). The underlying idea of developing the above-mentioned competencies is that teachers who possess a sufficient level of competencies to use ICT in their professional activities will be able to ensure high quality of education.

In this regard, both foreign and Ukrainian researchers mostly consider the issues of forming ICT competency of future teachers in the process their training. Thus, Kaiser and König [2] provided an overview on the current knowledge derived from empirical research on the structure of the professional competence of teachers and competence development during teacher education. Jusoh et al. [3] highlighted dimensions of the impact of mathematics teachers' competencies on the level of their creative teaching practices. For this purpose, the authors propose to include information and communication technology (ICT) to the Primary School Integrated Curriculum and the Integrated School Curriculum.

However, the continuous improvement of Web-technologies necessitates the formation of ICT competency not only of future teachers but also the continuous professional development of those teachers who already work in schools and higher education institutions. Accordingly, Cetinkaya, Erbas, Celikdemiret al. [4] found what a group of experts involving mathematics teacher educators and representatives of educational non-governmental organizations think about the competencies a Maths teacher educators should possess. The authors note that the matter of teachers' professional development, in particular their ICT competency, was quite controversial. It is ascribed to the fact that one group of the researchers attributed it to the competency area "Teachings", and the other group – to "Service to the Society". According to Petukhova and Spivakovskyi [5], Petrenko [6], this was entailed by the fact that ICT competency is an integral characteristic of a personality, which affects all teacher activities. Therefore, Vlasenko et al. [7], Morse et al. [8] proposed to tap the selection of Web tools to fill the PLE of Maths teachers on the basis of their activities.

Consequently, the need for the continuous formation of ICT competency of a teacher, including the one of a Maths teacher, is beyond dispute. One of the best ways to address this issue, according to the researchers (Malhotra and Goyal [9], Broderick [10], Heap [11]), are online courses that will help teachers navigate the space of Web-technologies and level up their ICT competency.

That is the reason why there have recently been appearing more and more courses that offer teachers to improve their skills in the field of information technologies. Thus, Coursera platform offers teachers a "Learning to Teach Online" course [12], which aims to train the teacher on how to improve the design of a course with the aid of the Internet technologies. Ukrainian Catholic University developed the "E-Didactics and Blended Learning" course [13], the purpose of which is to provide information on the possibilities of teaching courses in the blended format. Proposed by from Ukrainian teachers, the "Blended Learning: Recipes – Simple and Tasty!" online course [14], hosted on the Blended Learning Club platform, is intended for those who want to diversify their teaching practices and modernize methodological approaches to developing

training courses. Maastricht University (Netherlands) developed the "Problem-Based Learning: Principles and Design" course [15], during which the users practice applying tools that facilitate problem-oriented learning. The course developers provide an overview of online tools, share recommendations on the emotional inclusion of students in the learning process through social networks, creative tasks and mini-series.

Therefore, the idea of developing an online course for teachers to raise their awareness in the field of Web-tools is relevant. But, as stated by the authors of the "Eduget" platform [16], having a good idea is not enough for an online course to be a success. The whole host of factors that will interest the audience and encourage them to take the course should be considered. To ensure these factors when developing an online course, according to Krainer et al. [17], a model is needed that will be based on the needs of a teacher, particularly on all types of his/her activities.

As noted by Morrison [18], the online course model is a tool that describes the structure of the course, guides the user to the topic, removes distractions and ensures focus. The author points out that there are many models for designing curricula, but there are only a few that are specific to online designing of courses. The most well-known traditional models for developing online courses are the ADDIE (*Analysis, Design, Development, Implementation*, and *Evaluation*) principles [19], Dick Carey and Carey [20], and Rapid Instructional Design [21].

ADDIE is best considered as a classic representation of instructional design principles; its acronym associated with the five key principles of course design: *Analysis, Design, Development, Implementation*, and *Evaluation*.

Dick Carey and Carey Model [22] is a systematic model of instructional design, first introduced in 1978. It is sequential in nature similar to the ADDIE model. The model assumes the learner is active in the learning process, integrates the learner needs, skills and learning context into the design. It is a well-researched model that relies heavily on theoretical principles of learning, which no doubt is why it is a respected and widely implemented model in higher education.

Instructional Design Model for Online Learning (IDOL) [23] draws from the ADDIE principles, and the Dick, Carey and Carey model. It's perhaps best described as a "framework", since the authors of IDOL suggest it be used in conjunction with another design models, not as a replacement for. It presents 24 pedagogical dimensions for consideration during the design process.

Despite the prevalence of applying traditional models for online training courses, according to Morrison [18], what is required for a specific course that promotes the professional development of an adult and a professional is its specific flexible model of educational design. The researchers point to the need for a fresh approach to supporting targeted training of HEI teachers and creating a model that will help remove barriers to improving their ICT competency.

That is the reason why the purpose of our paper is to present a flexible model for an online course aimed at shaping a Maths teacher's ICT competency. Such a model, in our view, should take into account traditional models, but be specific to HEI teachers, i.e. be built on teachers' activities.

2. Method

As a basis for the development of the course we took a five-step ADDIE Model strategy (figure 1). This model of a systematic approach is best suited for the students' active participation in the learning process.

Over time, the content of each step (Analysis, Design, Development, Implementation and Evaluation) may change. Thus, in the future, not only the teacher but also the student will be the target audience. This will not only affect the first "Analysis" step but also change the further steps. In addition, the globalization of Web tools, the shift to engaging in Web 3.0

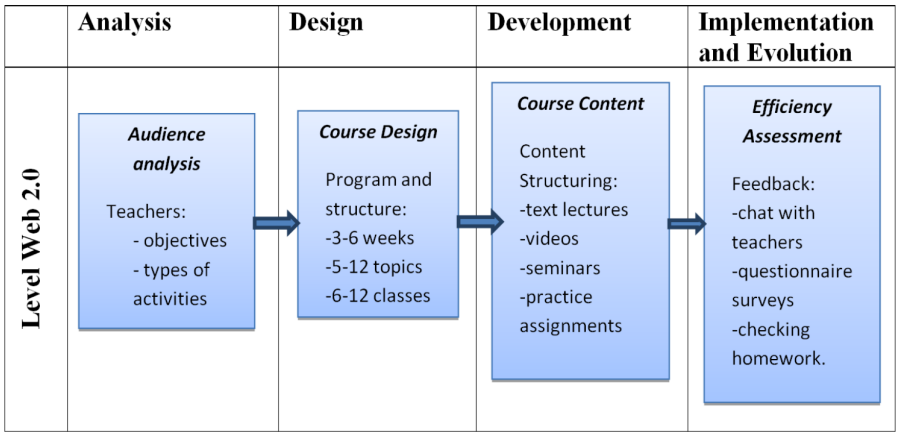

Figure 1. Model of the "Personal e-Learning Environment of the Math Teacher" online course.

learning, can accelerate the learning rates. Therefore, the duration of the course may shorten, and the content saturation may increase, which will entail adjustments to the "Design" and "Development" steps.

During the search phase of the study [7], Maths teachers were asked to independently select resources to fill their own PLE according to their activities, such as organizing the teaching process; searching for information; doing research, analysis and statistical processing of the information; doing the calculations; publishing popular science materials; publishing research papers; designing presentations collaborating; communicating; saving data. Based on this, we [7] developed a PLE model for a Maths teacher (figure 2).

Figure 2. PLE for a Maths teacher.

This model at the present-day stage of the development of Web 2.0 technologies involves placing a Maths teacher in the center, which results in the teacher becoming the starting point for creating an external network of nodes. Web 2.0 tools are designed to help teachers improve their skills and level up ICT competency. In table 1, we analyze the various tools in terms of their functionality for the teacher.

Table 1. Functionalities of Web 2.0 tools for a Maths teacher.

Type of Activity	Web 2.0 Tools	Functionalities
Organizing the teaching process	Moodle, Classroom, Coursera, Khan Academy, EDX	Implementation of subject-subject relations between teachers and students
Searching for information	Google Search, Google Scholar, Yandex, Wikipedia	Rapid access to open information around the world
Doing research, analysis and statistical processing of the information	Systat, MS Excel, Stadia, Statistica, Matlab	Use of open, free e-resources around the world
Doing the calculations	Matlab, Mathcad, Cantor, Math Editor, KAlgebra	
Publishing popular science materials	Youtube, Instagram, Ted Talks	Sharing audio and video files via the Internet
Publishing research papers	Scopus, Publons, Open Science in Ukraine	Participation in professional scientific communities, Web content creation (articles and publications)
Designing presentations	Power Point, Prezi, Canva, Prezi, Zoho Show, Keynote, Google Slides	Web content creation (presentations, reports, audio and video clips)
Collaborating	Blackboard, OneNote, Evernote, Google Docs	Exchanging good practices and information, expanding the space in which communication takes place
Communicating	Facebook, Twitter, LinkedIn, Yammer, Skype, Zoom, e-mail	
Saving data	Skydrive, Google Drive, Dropbox	Storing large amounts of data, unrestricted access to them from any device

However, over the course of time, as Web tools evolve, we will see a shift to Web 3.0. The concept of Web 3.0 involves the creation of a reliable, flexible, optimized and at the same time

"user-friendly" set of technologies and standards that would allow users, wherever they are, to identify any device nearby and create a network with it.

In this case, in the center of the PLE model, along with the teacher, there will be a student. And this is primarily related to the redistribution of roles between students and teachers because a teacher, trying to match up to the level of a student, begins to learn from the student, brings the student to the creation, dissemination, improvement of educational content. This way, the teacher will have to move from the formal transfer of knowledge to assisting the students in gaining it. The teacher becomes rather an advisor and a mentor for the student. Such changes will affect the modernization of the teacher's PLE and will require improvement of the "Design" and "Development" of a course due to the changes in the teacher's PLE.

The presented "Personal E-Learning Environment of the Maths Teacher" course [24] is designed to prepare the teacher for these changes (figure 3).

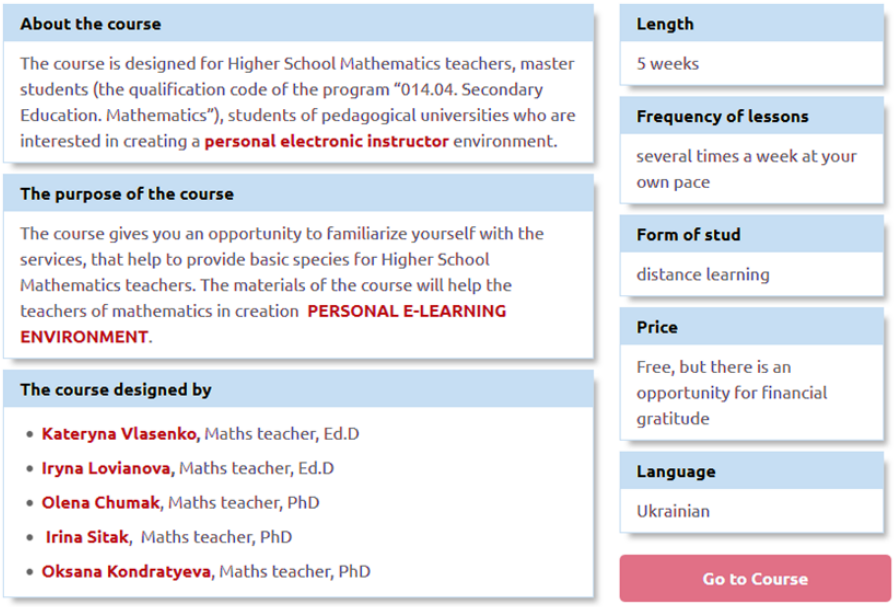

Figure 3. The webpage of the "Personal e-Learning Environment of the Maths Teacher" online course [24].

This online course is designed for 5 weeks to be worked through at the pace selected by a teacher. If desired, the user can pass the course faster, but the optimum pace is considered to be the one that provides for 2 lessons per week. Each lesson is packaged with a short text lecture, a video, a tutorial and a practice assignment. Gradually working out the class tasks, the teacher masters various Web 2.0 tools. Ranking of Web 2.0 services and their distribution in accordance with the types of teacher activities provides for the development of useful PLE, improves the level of Web tools mastery, helps to increase teachers' ICT competency.

3. Results

The experiment involved master's students majoring in Mathematics in Donbas State Engineering Academy, Kryvyi Rih State Pedagogical University, Berdyansk State Pedagogical University, a total of 50 volunteers. At the beginning of the experiment, the participants were randomly split into control (CG) and experimental (EG) groups. In the control group, 26 students studied the "Methods of Teaching Mathematics in a Specialized School (MTMSSh)" discipline following the traditional university program. In the experimental group, 24 students

when studying MNMSH took the "Personal e-Learning Environment of the Maths Teacher" online course [24].

The indicators for the effectiveness assessment of the developed course were the levels of the ICT competency formation. Through the analysis of the scientific literature [7], [25], 4 levels of the ICT competency were differentiated: very low, elementary, normative, high. To determine the higher education seekers' awareness about the use of various Web 2.0 tools, we applied special testing [26]. It included questions, associated with information access and management, information creation and presentation, problem-solving, decision-making, communication, creative expression and empirical reasoning. Respondents who received less than 30% of positive responses were classified as very low. Respondents who scored 30-50% – Elementary; 50-70% – Normative. Respondents had a high level, answering more than 70% of the questions. The analysis of the entrance level of the students' ICT competency showed no significant difference between the levels of its formation in EG and CG students (table 2).

Table 2. The distribution of the respondents by the levels of ICT competency formation at the beginning of the experiment.

Level Groups	Very low	Elementary	Normative	High
EH, 26 persons	5,5%	54%	19%	21,5%
KH, 24 persons	5,9%	52%	20,2%	21,9%

The graphical representation of the results is shown in figure 4.

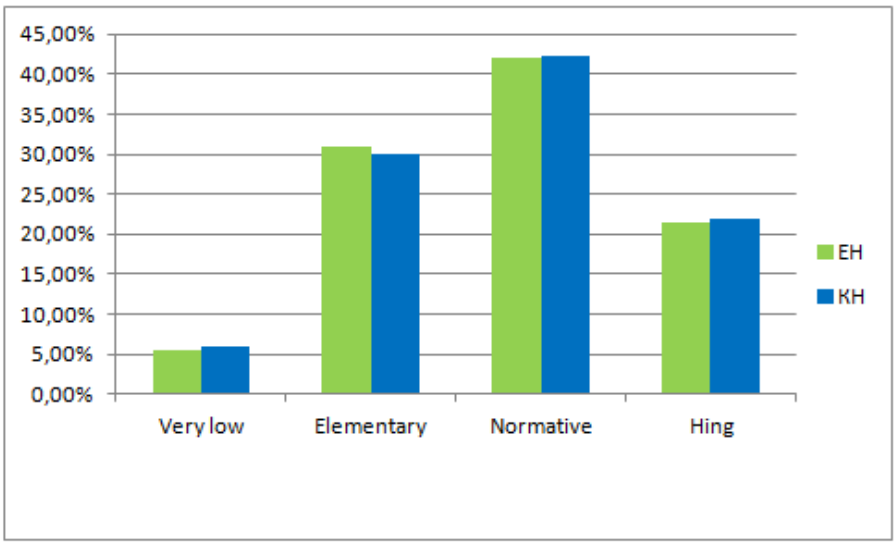

Figure 4. The distribution of the CG and EG students by the levels of ICT competency formation (at the beginning of the experiment).

At the end of the experiment, CG and EG students did the test again [26].

The results of the final assessment of the experimental and control groups are presented in table 3.

Table 3. TThe distribution of the respondents by the levels of ICT competency formation at the end of the experiment.

Level Groups	Very low	Elementary	Normative	High
EH, 26 persons	3,5%	36,5%	35,8%	24,1%
KH, 24 persons	4,9%	48,7%	23,5%	22,9%

As can be seen, at the end of the experiment, in EG we observe the redistribution of the percentage of students towards the normative and high levels. The overall increase was 19,9% compared to 4,3% in CG.

Thus, at the end of the experiment, there was an increase in the normative level of the ICT competency formation in EG by almost 16,8%, while with the CG students this level increased only by 3,3%. The number of course users having a high level of ICT competency in EG increased by 2,6%, whereas in CG – only by 1%. The graphical representation of the results is presented in figure 5.

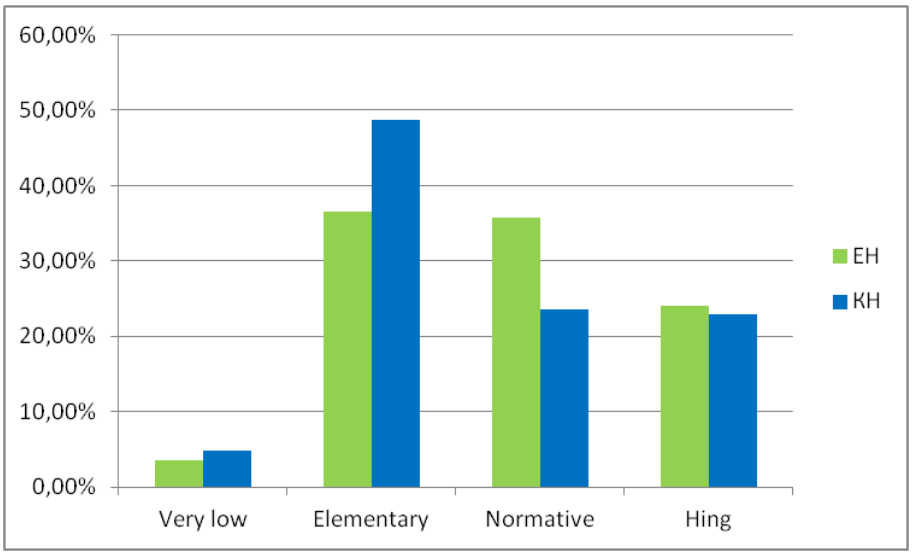

Figure 5. The distribution of the CG and EG students by the levels of ICT competency formation (at the end of the experiment).

4. Discussion

The search for approaches to the development of all-age students' ICT competency raises broad interest in all countries of the world. Thus, Jusoh et al. [3] analyze the experience of reforming education in Malaysia through the transformation of the Primary School Integrated Curriculum and the Integrated School Curriculum. The curriculum was complemented with such components as creativity and innovation, entrepreneurship and information and communication technology (ICT). However, as the Australian Curriculum Assessment and Reporting Authority noted [26], since the developed economies and societies increasingly rely on workers' and citizens'

ICT competency, and while schools already employ technologies in learning, they still need to increase their effectiveness significantly over the next decade.

This is agreed on by the Ukrainian researchers Morze et al. [8] who highlighted the formation of students' ICT competency on the basis of the TOTE model. The TOTE model accords to the proposed stages: 1.Test: determine the current state of the ICT competence of secondary school graduates; 2. Operate: the development of an ICT competence model of students in learning computer science; 3. Test: students' ICT-competence formation re-assessment; 4. Exit: recommendations for ICT competence forming. The researchers proposed a model for forming high school students' ICT competency in the process of teaching IT. Cetinkaya, Erbas, Celikdemiret al. [4], when studying the Turkish education system, noted that the issue of further teacher training, in particular their ICT competency, needs special consideration not only in secondary school but also while acquiring higher education. This opinion is supported by the research by Kaiser and König [2], who study the development of teacher competence during the transition from teacher education to teaching practice.

Therefore, ICT competencies should take a leading place among the other teacher competencies. And their formation should be continuous at all levels of education: at school, in higher education, and then during teaching activities. This is linked to the constant development of ICT technologies and the future transition from Web 2.0 to Web 3.0 resources. A universally applicable way to develop ICT competencies, according to Malhotra and Goyal [9], Broderick [10], Heap [11], are online courses that can be used both in training future teachers in graduate schools and after they are employed.

The experience of the"Eduget" platform authors [16] confirmed our view of the usefulness of developing the "Personal e-Learning Environment of the Maths Teacher" online course [24] as an effective way to increase Maths teachers' ICT competency. We folloed their recommendations into account and applied a set of factors that will interest the audience and encourage them to take the course. We also took into consideration the opinion of Krainer et al. [17], and while designing the online course presented the model, based on the teachers' needs, in particular, on all types of their activities. Due to this, the developed online course is based on the ADDIE Model. The application of this model provides for flexibility of the educational process, through which a higher education seeker is able to independently set the pace of passing the course and completing the assignments. In the future, this model can be transformed to master Web 3.0 resources. The results of the experiment among master's students showed a positive effect of this course on the formation of ICT competency of future Maths teachers. Besides, positive feedback was received from already working Maths teachers. However, in the future, there may be scope for conducting the experiment among working teachers, in order to test the effectiveness of the course on the more experienced audience.

5. Conclusions

The analysis of the pedagogical literature suggests that the development of online courses in the learning process is at the height of its popularity. The use of online courses is an effective means of increasing the ICT competency of both teachers and seekers of higher pedagogical education. The analysis of the results of the questionnaire survey among HEI Maths teachers confirmed their insufficient level of ICT competency and the willingness to increase it with the help of our "Personal e-Learning Environment of the Maths Teacher" online course.

The placement of the course on the "Higher School Mathematics Teachers" platform provided free access to the course materials. The development of the course model, its structure and topics should be based on the analysis of Maths teachers' activities, the existing educational resources that support online education.

The discussion on the forum ensured increasing in the amount of the submitted educational material, the range of forms of presenting educational content. The results of the experiment

among master's students and the analysis of the opinions of the forum participants confirmed the possibility of the course being used by Maths teachers in higher school.

Among the directions for further research, we see the introduction of the developed online course not only in the process of teaching master's students but also in the process of improving ICT competency and professional development of working Maths teachers.

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