Sofia University “St. Kliment Ohridski”,
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Personalization of secondary school mathematics education through the use of modern information technologies

Abstract of Ph. D. Thesis
of
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for the award of educational and scientific degree "Doctor"
in the Professional Field 1.3 "Pedagogy of learning in..."
PhD program "Teaching Methodology of Mathematics and Informatics"

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Sofia, 2022

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GENERAL CHARACTERISTICS OF THE THESIS

1. RELEVANCE OF THE PROBLEM

Personalized learning is a challenge of educational systems all over the world and therefore it is also a challenge of educational policies in Albania.

The many changes that are taking place day by day around the world bring attention to the education policymakers' review of the need for a periodical review of the policies in terms of learning mathematics, turning them into a necessity and increasing the quality of mathematical thinking and capabilities to solve as much as possible actual practical problems of our daily life.

In recent times, the digitization of many aspects of life, the ubiquity of data for making personal decisions involving initially education and career planning, and, later in life, health and investments, as well as major societal challenges to address areas such as climate change, governmental debt, population growth, the spread of pandemic diseases and the globalizing economy, have reshaped what it means to be mathematically competent and to be well equipped to participate as a thoughtful, engaged, and reflective citizen in the 21st century. (OECD, 2018)

Relying on the trend of personalization in all spheres of life, the century we are living in came with a completely different approach from that of the 20th century in terms of educational policies. The characteristics of education of this century are:

1. Personalized learning;
2. Equality, diversity, and inclusiveness;
3. Learning through doing;
4. Changed teacher roles;
5. Relationships with the community;
6. Technology;
7. Professionalization of the teacher. (Bolstad, et al., 2012).

There is no coincidence that the first point of these key characteristics is the personalization of learning. It is placed in coherence with personalization in all aspects of life, which undoubtedly will be intertwined and strongly supported by other important components like ICTs.

Since the teaching of mathematics is the basis of the teaching of all sciences the personalization of the teaching of mathematics takes on a special role in the educational system as a whole.

Based on the arguments above, in general terms, a personalized learning model can be expressed as follows in Figure 1.

Personalized learning = Student's need + Learning modality + ICT's tools support

Figure 1 Personalized learning model

This PhD thesis is **a model of a process** that requires a deep understanding of the skills, needs, and talents of the students to be combined with many other psycho-pedagogical factors, on one hand, and the continuously updated implementation of educational technology innovations for personalization of teaching and learning math, on another.

2. OBJECT AND SUBJECT OF THE RESEARCH

The **objects** of study in this doctoral thesis are:

1. The technological base of Albanian schools as a key tool to support the personalization of teaching in general and mathematics in particular.
2. Mathematics teachers in the secondary schools in Albania;
3. Students in the secondary schools in Albania.

The **subjects** of the study are:

1. The required conditions for mathematics teachers in Albania to provide personalized teaching with the support of ICT tools;
2. The digital competencies of math teachers in Albania;
3. The sensitivity of Albanian high school students to personalized ICT-supported teaching/learning of mathematics and the learning outcomes.

The requirements of school principals the educational policy-making for modern ICTs infrastructure in schools and the development of a model for teacher training (or recommendations) are the key factors for the research.

3. RESEARCH QUESTIONS

The research questions of this study are:

1. Is the existing technological base in the Albanian schools and the digital competencies of the Albanian teachers good enough for personalization with ICT-supported mathematics education?
2. How important is the continuous training of teachers in terms of learning modalities and support of ICTs tools, for active contemporary teaching in mathematics?

3. Is the personalization of math learning through ICT increasing students' performance, as well as their motivation and self-confidence to deal with math?

4. HYPOTHESIS

The hypotheses of this study are:

1. The insufficiency of ICT tools in Albanian schools is a barrier to the wide adoption of educational technology for mathematics learning personalization;
2. The lack of digital skills and competencies of Albanian teachers slows down the process of personalization of math teaching in Albanian schools;
3. The understanding of the students learning styles and the use of ICTs tools in mathematics teaching is a necessity for personalized learning, in recent years;
4. The use of ICTs tools in teaching/learning mathematics leads to higher grades and better self-esteem and motivation for students.

5. OBJECTIVES

The **objectives** of the research are:

1. To collect data to analyze the real situation of the technological base for teaching that exists in our schools, and in parallel to investigate the perception of mathematics teachers in secondary school on the role of ICTs tools in personalizing mathematics teaching.
2. To train a group of secondary school mathematics teachers to improve their skills and competences firstly in the factors that lead to the personalization of teaching and secondly in the efficient use of SmartBoard, GeoGebra and Kahoot!, to personalize the teaching of mathematics, bringing a model to be followed by training agencies in Albania.
3. To measure the extent to which ICT tools influence the support of the personalization of mathematics teaching, the development of mathematical competencies (student outcomes) as well as their motivation to learn mathematics.

6. TASKS

To achieve the purpose of the dissertation, the research was based on the following tasks:

1. Analysis of the ICT infrastructural base in the Albanian educational system, as well as the digital skills and competencies that the Albanian mathematics teachers have, to apply the ICT tools in teaching.
2. Analysis of data regarding frequency, information, and diversity of use of ICT to personalize math learning in Albania.
3. Analysis of the role the training of mathematics teachers has, concerning students' learning styles and adaptation to ICT tools for them
4. Training of a group of mathematics teachers on the use of some platforms and technological tools to personalize the mathematics teaching.
5. Analysis of the role, played by the use of ICT tools for the personalization of teaching and learning of mathematics, as well as the reactions of teachers and students involved in the study.
6. Case study on the implementation of ICTs tools (SmartBoard, GeoGebra, Kahoot!) in 3 schools to personalize the teaching/learning of mathematics.

Case study 1: Personalized teaching and learning mathematics through problem-solving, supported by SmartBoard.

Case study 2: The efficiency of dynamic GeoGebra software, in giving differentiated instructions based on student levels, on treatment concept of functions, in the eighth grade.

Case study 3: The impact of learning games on the approach of secondary school students towards the subject of mathematics and the development students of computational thinking.

7. RESEARCH METHODS AND TOOLS

1. **Analysis of data regarding frequency, information, and diversity of use of ICT to personalize math learning**
   1.1. Literature (documentary} review of the regulatory framework, based on the ordinance, reports, and government strategies, in order to:
      a) To determine the conditions in Albania for offering personalized teaching in math through ICT.
      b) To investigate the technological infrastructure.

1.2. Survey on how the teachers use the ICTs in teaching math – statistical analysis

1.3. Interviews and discussions with teachers – qualitative data collection

2. **Training of a group of mathematics teachers on the use of some platforms and technological tools to personalize the mathematics teaching**

2.1. Post-training questionnaire regarding of the effectiveness of the education according to:

a) The level of knowledge about the support that ICT provides in relation with learning styles to personalize mathematics teaching/learning.

b) Skills to build and follow a Personal Learning Plan (PLP) for personalizing math learning.

c) Identification of main barriers in front of teachers in order to personalize math teaching

d) The support that ICT tools provide for personalized learning of mathematics

The questionnaire aims to investigate the third hypothesis.

3. **Case study on the implementation of ICT (SmartBoard, GeoGebra, Kahoot!) in 3 schools to personalize the teaching/learning of mathematics.**

This part of the study brings results from the pilot implementation of personalized teaching mathematics at 3 schools. Experimental and statistical methods are used.

Case study 1: Use of SmartBoard to support problem-solving, for students with different learning styles, seventh graders.

The study examines the empowerment of logical and critical reasoning during problem-solving, through personalized mathematics learning and active teaching methods, supported by SmartBoard.

1. **Independent variable**: Problem-solving with pencil, blackboard, paper, and SmartBoard
2. **Dependent variables**: the results of the third quarter as well as the improvement of problem-solving techniques.

The proces follows the path:

- **Phase 1**: Analysis of the situation of the indicator of dependent variables for the second quarter.

- **Phase 2:** The dependent variables is influenced by the independent ones.
- **Phase 3:** The indicators of the dependent variables are measured through math test for students. Analysis of results are used to investigate whether the indicators have changed and how.

Case study 2 explores the use of GeoGebra in terms of visualization, demonstration, group work, or mathematical modelling of problems, related to the concept of function, and incrasing the level of personalization, motivation, and identification of talent in learning mathematics.

This case study looked at the following variables:

1. **Independent variable:** teaching method (traditional with pencil, blackboard, GeoGebra Software)
2. **Dependent variable:** tracked by a post-test of achievements that include:
    a. Capability for discovering laws, using the meaning of algebraic functions and symbols to model mathematical relationships and situations.
    b. Problem-solving skills, related to functions.
    c. Skills for description and mathematical modelling of problem situations, based on "size" concept, with a context from real life.
    d. Skills for formulating conjecture and judgment of conjectures.
    e. Skills for planning and structuring mathematical arguments for the conclusions found.
    f. Capability to create variety of representations of a problem and its mathematical model – by drawings, by the use of ICTs, algebraic mathematical concepts, and graphics.
    g. Capability to link new mathematical concepts and models to those previously acquired by mathematics and other fields and understanding their formation

The proces follows the path:

- **Phase 1**: Analysis of the level of knowledge on the topic "Functions"
- **Phase 2:** The dependent variables are influenced by the independent ones
- **Phase 3:** The indicators of the dependent variables are measured through math test for students. Analysis of results are used to investigate whether the indicators have changed and how.

Case study 3 aims to investigate the effect of learning games on the development of logical, critical, and computational thinking of students at grades 5. – 9. in the secondary school "Imelda Lambertini" in Elbasan, Albania.

This case study investigates the role that the usage of the Kahoot!, plays for:

a. Students' motivation;
b. Self-esteem and cooperation of students;
c. Strengthen positive attitudes toward learning mathematics;
d. Logical thinking development;
e. Computational thinking development.

Independent variables: critical and computational thinking in problem-solving and testing knowledge with pencil and paper and Kahoot!

Dependent variables: results achieved, as well as motivation and emotional behaviour of the students.

The proces follows the path:

a. **Phase 1:** "Contest of challenges in mathematics". All students of the selected classes participate. Each of them chooses another student to challenge him. The challenge relates to the computational thinking.
b. **Phase 2:** "Evaluation of students' achievement through the Kahoot! application". The dependent variables are put under the influence of independent ones. Tests were performed by pencil and paper, and using the Kahoot! application.
c. **Phase 3:** The indicators of the dependent variables are analysed to investigate whether they have changed and how.

Oral interviews with the teachers of the experimental groups are taken to investigate their perceptions.

The study is **development oriented**.

STRUCTURE AND CONTENT OF THE PHD. THESIS

The content is structured in 6 chapters:

- Chapter 1. Overview of the role of ICT tools in teaching mathematics. Approaches to their applications in the Albanian context.
- Chapter 2. Personalized learning in mathematics.

- Chapter 3. Use of ICT in teaching mathematics in Albania: state-of-affaire.
- Chapter 4. Training teachers to provide personalized math education, supported by ICT tools.
- Chapter 5. Validation of teachers' training on personalized math teaching, supported by ICTs.
- Chapter 6. Influence of ICT-supported personalized learning of mathematics on the motivation to learn mathematics.
- Conclusions.

CHAPTER 1. OVERVIEW OF THE ROLE OF ICT TOOLS IN TEACHING MATHEMATICS. APPROACHES TO THEIR APPLICATIONS IN THE ALBANIAN CONTEXT.

The chapter presents a literature review on the role that ICT plays in personalizing mathematics learning. It contains a systematic analysis of the evolution of the mathematics learning process, from pencil and paper teaching to modern mathematics teaching. The main focus is how the evolution of technological tools supports active mathematics teaching. In the second part, the chapter presents a national context review in terms of the regulatory framework and the school ICTs infrastructure in Albania.

After exploring the role of the ICTs in mathematics education and the "Trinoma" (Figure 2) phenomenon in the development of the abstract thinking, some of the benefits of using ICT tools in learning mathematics are extracted.

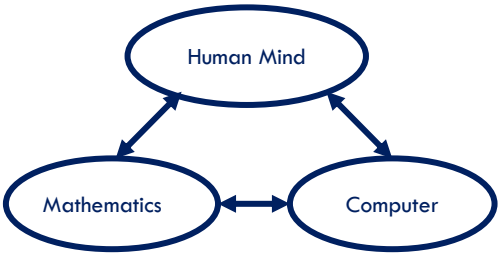

Figure 2. Trinoma the human mind - mathematics – computers

Some of them can be defined as follows:

a) The **reinforcement of concepts through multimedia** plays an important role in sensory components and allows the use of a wide variety of learning modes.
b) **Visualizing of 2 and 3-dimensional geometric** figures through graphic illustrations encourages students to experiment with them.

c) The ability of computers to enable us **to personalize learning** of mathematics.
d) **Motivational and interactive computer skills.** It is a characteristic of pre-university students to want to deal with math exercises and problems that require a shorter duration to solve. They feel confident and motivated to try again when they have completed an exercise quickly and accurately.
e) **Developing computational thinking through the use of ICT**.

The exploration of the ICT development in Albania and of the National policies allow to summarize the digital competences the educators need to possess to foster effective, inclusive, and innovative learning strategies, using digital tools.

Digital competencies mean, **first of all,** that teachers know the role, benefits, and opportunities that ICT tools offer in teaching mathematics.

Secondly, they must be able to search, gather and select the right information that makes it possible to personalize the mathematics learner. In addition, they should be critical analysts of materials and platforms served on the internet.

Third, after critical analysis of the platform or software chosen, they should reflect on it.

Undoubtedly, the coordination of all these components brings the immediate need to redefine the skills they currently have.

In the same time the competency-based learning of mathematics at school is focused on the development of the 6 key mathematical competences:

1. **The solution to the problem situation**
2. **Mathematical reasoning and verification**
3. **Mathematical thinking and communication**
4. **Conceptual connection**
5. **Mathematical modelling**
6. **The use of technology in mathematics**

In conclusion, the intervention in Albania should be done in three main directions in parallel:

1. Continuously trainings of teachers in two directions – firstly to personalize teaching based on active methodologies, and secondly for a meaningful use of ICT in schools, not only as a facilitator of their daily work at school, but as a supporter of the learning process as a whole, supporting students to advance according to their abilities and needs in the learning process

2. Creating an European model of teachers with the characteristics set out in "The UNESCO ICT Competency Framework for Teachers" by setting up a structured system of policies and priorities, based on an analysis of the strengths and weaknesses of our teachers in terms of competence digital.
3. Taking measures to acquire digital competence in terms of teaching mathematics at the university, coordinating work with universities that prepare teachers to introduce as a special curriculum the preparation of technological didactic tools for teaching.

CHAPTER 2. PERSONALIZED LEARNING IN MATHEMATICS

This chapter presents the general treatment of personalized learning and analyses the mathematical context of the four main components of successful personalized learning.

- Reflecting on students and setting their goals
- Targeted instruction
- Flexible path and pace
- Collaboration and creativity.

The first part provides an example for construction of schemes for understanding the essence of the problem and accompanying it by the pedagogical simulation apparatus (Figure 3).

Example: The teacher could present to the students the concept of the Least Common Multiple (LCM) by a simple situation of learning: "One flower is watered once in 3 days and another once in 2 days. If today, both flowers are watered, after how many days will both flowers be watered again at the same time?

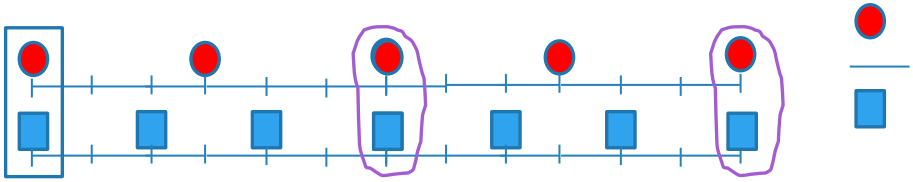

Figure 3 Graphic illustration of situational solution.

The pedagogical simulation apparatus is built through tasks and questions such as:

– *Mark with numbers 6 times from the watering of the first flower. (3, 6, 9, 12, 15, 18….)*

- *Mark with numbers the 6 times from the watering of the second flower (2, 4, 6, 8, 10, 12….)*
- *After how many days will they be watered again at once? (6, 12, 18, …)*
- *When are they watered for the first time at once?*
- *On what day are the flowers watered for the first time at the same time?*
- *How many times will this be for the first flower?*
- *What about the second flower?*

The **Targeted instructions** section provides a tool to development a Personal Plrofile Learning (PPL) for each student, based on four frames (Table 1):

1. Demographics
2. Academics
3. Learning capacity
4. Aspirations learning drivers (Digital Promise)

Table 1. Student Personal Profile Learning Form (PPL)

Name:……..	**……**	**Subject:**		**Class …….**
Frames	**Characteristics**			
Demographics	General Identification	Family/living arrangements	Family history of formal learning	Other information
Academics	Test scores	Progress data	Formative/interim assessments	Current academic goal(s)
Learning capacity	Skills	Habits	Dispositions	Current non-academic goal(s)……
Aspirations, learning Drivers	Current preoccupations	Hopes for the future	Factors that propel learning	Other goals

The role of the tool is to provide a **Flexible path and pace, Collaboration and Creativity** in teaching and learning.

The full framework of the chapter concludes with some instructions on how the personalized math lesson can be accomplished and which tasks the teacher must accomplish.

It concludes that the personalized teaching and learning of mathematics through ICTs provide impact on all the main goals of mathematics learning (Figure 4).

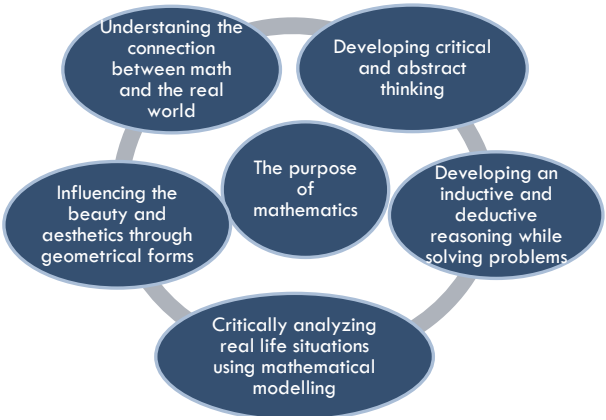

Figure 4.The purpose of learning mathematics

International Association for Technology in Education (ISTE) has set very high standards for students, ranging from "Learning to use technology" to "Transformative learning with technology", but achieving these standards requires qualified teachers and ICT tools to support the process.

Some aspects that would take on the current situation in Albania would be:

- The types of ICT tools that teachers have at their disposal for teaching in the schools where they teach.
- Personal perception of the use of ICTs tools in mathematics learning.
- Their professional motivation is to be trained in the use of ICT in teaching.
- Personal experiences with using ICTs tools to personalize learning.
- Difficulties they encounter when using ICTs tools in teaching mathematics

CHAPTER 3. USE OF ICT IN TEACHING MATHEMATICS IN ALBANIA: STATE-OF-AFFAIRE

Chapter 3 aims to shed light on analysis and interpretation of the questionnaire developed with the target group of teachers of mathematics in secondary school about these issues:

a. The types of ICT tools that teachers have at their disposal for teaching in the schools where they teach.
b. Their perception of the use of ICTs tools in mathematics learning.
c. The interest they have in being trained in the use of ICTs tools in teaching.
d. Personal experiences with the use of ICTs tools in the classroom.
e. Difficulties encountered by mathematics teachers in Albania in using ICTs tools in teaching mathematics.

Data about "**The situation of the use of ICT in teaching mathematics in Albania**" was collected through a questionnaire, filled-in by 210 mathematics teachers, from 4 Regional Directorates of Pre-University Education.

The results show that the difficulties that teachers encounter in personalizing teaching through ICT range from parents' scepticism about learning math through ICT to a limited amount of teaching platforms related to mathematics, translated into Albanian (Figure 5, Figure 6).

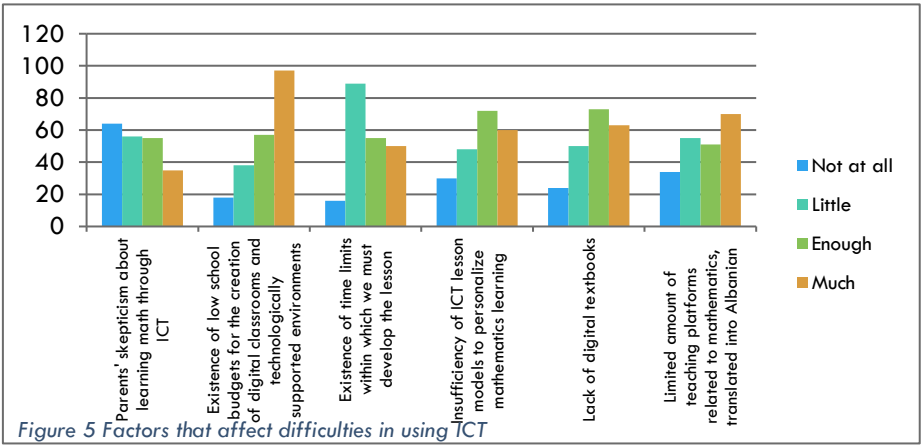

Figure 5 Factors that affect difficulties in using ICT

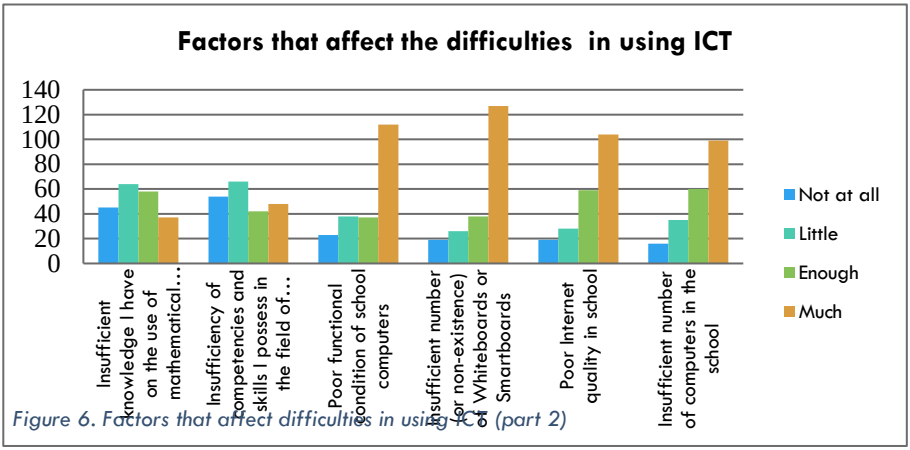

Figure 6. Factors that affect difficulties in using ICT (part 2)

The data, collected through the questionnaire, showed that the teachers" digital competences need significant improvement (Figure 7).

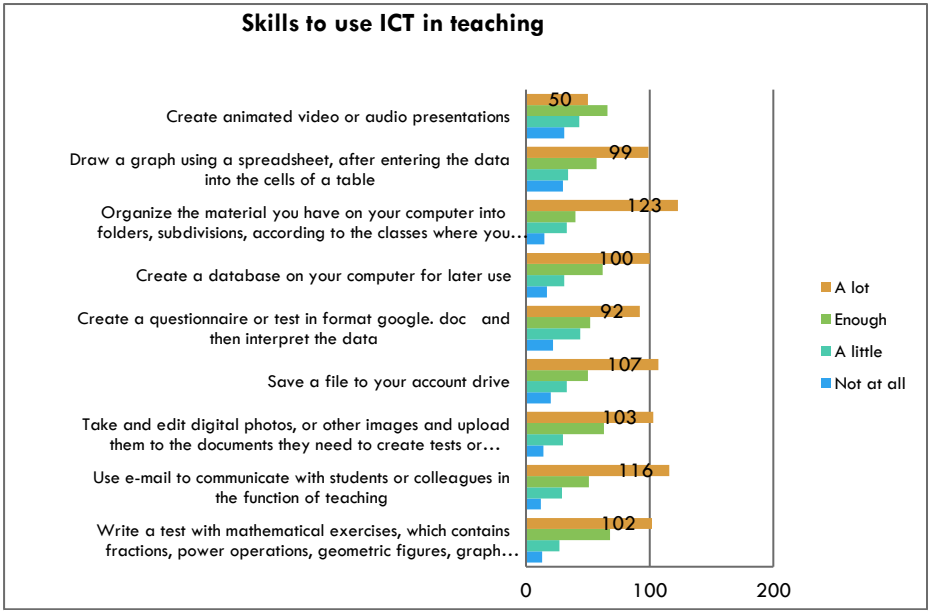

Figure 7. Skills to use ICTs in teaching (excerpt)

The results show that teachers possess the basic skills to use of educational ICTs tools in teaching. Only few of them efficiently use platforms for teaching or learning games in math classes.

Almost half of the teachers possess little or not the majority of the basic skills and competencies they need to carry out a productive learning process.

The questionnaire results were accompanied by a semi-structured interview, delivered with 8 teachers. Their answers reveal some conditions and good practices, related to the real personalized math teaching in class. They emphasize also that an important element of the process of personalization of teaching/learning is to setup the use of ICT tools to be close to each student's learning modalities. The questionnaire developed with the teachers throughout Albania, as well as the interviews conducted with mathematics teachers, highlighted the need for training in the field of teaching through ICT to personalize mathematics learners.

CHAPTER 4. TRAINING TEACHERS TO PROVIDE PERSONALIZED MATH EDUCATION, SUPPORTED BY ICT TOOLS

The chapter presents the aspects of training math teachers in Elbasan, Albania, about personalized learning in mathematics based on the learning styles of students and the ICT support, as well as the opinions of some teachers on these issues.

One of the main points to be reflected directly from the analysis of the questionnaire, filled out by the mathematics teachers, is the low number of trainings they had received regarding the use of ICTs tools in teaching.

Purpose of the training

The purpose of the training conducted with the teachers of mathematics in the region of Elbasan as well as the teachers of mathematics of the non-public school "Vincçens Prendushi" in Durrës (part of the network of Catholic schools in Albania) was to **provide a model for teacher training** based on aspects of teaching student-centred learning styles, supported by educational technology to personalize the teaching of mathematics.

Training objectives

At the end of the training teachers should be able to:

1. Recognize students' learning styles as a powerful tool for lesson planning and finding effective methods to develop subject competencies.

2. To adapt the efficient technological educational tool, based on the learning styles of the students to personalize the teaching of mathematics.
3. Use SmartBoard, the GeoGebra app, and Kahoot! App to support teaching and students' personalized learning in mathematics.

Duration of training

The training took place from 20 to 21 March 2021, face-to-face.

Topics of training

The main topics of the training were:

1. Learning styles in general and in mathematics in particular
2. Technology and learning styles
3. Personalized learning in mathematics, based on the learning styles and technology support
4. Use of SmartBoard, GeoGebra, and Kahoot! to support personalized teaching and learning in mathematics.

Methodology

Teacher training followed these steps:

1. Mixed structured and unstructured interviews with a group of math teachers to gather information about their students' learning styles, taking them into account in finding supportive methods and techniques to realize personalized teaching. The interviews also focused on gathering information on the educational technology platforms and software they used most in teaching mathematics.
2. Determination of the **training topics** and resources, based on the interview results.
3. **T**raining delivery under control of the the Head of the professional network of teachers.
4. post-training questionnaire on the effectiveness of the training. Determination of the schools where the pilot experiments will be implemented.

Results and recommendations

The training showed that, despite the work experience of mathematics teachers, despite the high level of science they have in mastering the subject, they must constantly apply teaching methods that combine psycho-pedagogical and methodological aspects with the support of ICTs tools. Student success in

mathematics will only be achieved if teachers carefully combine the following four components:

1. Personalized learning
2. ICT support
3. Adapting teaching strategies to students' learning styles.
4. Optimal management of all stages of the learning process

The elaboration of the training results, questionnaires and interviews lead to the following recommendations to the policy-makers:

1. Possession of digital competencies for the application of educational technologies in the teaching process should be an obligation for teachers and to be controlled and followed with transparency by the authorities. It is recommended that the qualification tests that take place after (5, 10, and 20 years of work) also include questions that test the digital skills of teachers.
2. Monitoring of Teacher Training Agencies, for a more equal distribution of the developed training, giving the training related to ICT tools in education the appropriate space or reorganizing the training agencies by profiling them to offer training in 1 - 2 categories.
3. Monitoring of the training they perform after the training plan has been approved by the competent bodies, bringing under control a fair distribution of training according to the fields.
4. Establishment of teacher mentoring structures by qualified teachers towards the use of ICTs tools in teaching, motivating the latter for the service provided.

CHAPTER 5. VALIDATION OF TEACHERS' TRAINING ON PERSONALIZED MATH TEACHING, SUPPORTED BY ICTS

The teachers' training finished with the identification of a group of teachers who to implement pilot experiments on personalized teaching of math through ICT tools. Specifically, the experimental part of the study focused on three experiments that bring the benefits of using specific educational technological platforms, to personalize secondary school mathematics teaching.

Case study 1: "Use of SmartBoard to support problem-solving, for students with different learning styles, for seventh graders" examined the empowerment of logical and critical reasoning problem solving, through active teaching methodologies, supported by SmartBoard, to personalization mathematics learning.

Case study 2: "The efficiency of dynamic GeoGebra software, in giving differentiated instructions based on student levels, on treatment concept of functions, in the eighth grade" explored how the use of GeoGebra in terms of visualization, demonstration, group work or mathematical modelling of problems related to the concept of function, risk at the level of personalization, motivation, identification of talented in learning mathematics.

Case study 3: "The impact of learning games on approach of secondary grade students towards the subject of mathematics and the development students of their computational thinking", aimed to investigate the effect of learning games on the development of logical, critical, and computational thinking to students of grades 5. – 9. in the secondary school.

This chapter analyses these 3 experiments.

In the first experiment, the treatment of additional teaching materials, accompanied by the competencies of the field developed by each task or group of tasks, as well as with differentiated content, created the opportunity for students to work independently.

Their work in groups according to defined activities increases interaction and empowers them from the point of view of decision-making. The plan of activities implemented in the experiment is a model of how the problem solving could be integrated with personalized teaching and, at the same time, with the development of all the competencies in the field.

The second experiment provides a model of how to start a personalized learning with identifying the strengths and weaknesses encountered in the pre-test. The structure of the experiment, the detailed plans according to the students' levels, the exercises and problems of applied character, the solution of which was supported by GeoGebra, bring positive changes in the class dynamics as well as in the students' interest to deal with mathematics, in addition to increasing performance of students. The shift of math learning, beyond the classroom walls, to their home computers, being practised with the GeoGebra app speaks to a boost of formal from informal learning in their homes.

The third experiment brings another model of how the game-based mathematics learning could be personalized by simultaneously developing critical and logical thinking and computational thinking. In this experiment, it was taken into account that students can learn anywhere, and in any way. The game in Kahoot! served not only to highlight each week students' weaknesses through simple weekly quizzes but stimulated their desire to create own Kahoot! with answers, and massified the game process by dealing with math. This activity encouraged students to raise their level of reasoning.

The findings of the study show that to personalize mathematics learners, the teacher needs:

- Knowledge of students' learning profile
- Creating detailed plans and strategies according to the level of students
- Finding effective teaching methods and techniques
- Supporting students with source material differentiated in content
- Choosing the right ICTs tools to support the whole process.

The successful implementation of the experiments confirms the effectiveness of the training and brings facts that personalized teaching of mathematics supported by ICTs tools brings not only higher results in students' mathematical thinking, but also increases their motivation and self-esteem.

CHAPTER 6. INFLUENCE OF ICT-SUPPORTED PERSONALIZED LEARNING OF MATHEMATICS ON THE MOTIVATION TO LEARN MATHEMATICS

The Chapter 6 addresses the role played by the use of educational technologies in teaching mathematics to motivate students and increase their self-esteem. The results were based on the analysis of a questionnaire made by students who underwent the experiment.

After experiments in the three schools, a questionnaire was submitted to the students of the experimental groups. It investigates the frequency of using ICT tools to develop different activities related to the teaching of mathematics in their schools. It also collected students' opinion regarding the importance of the use of ICT in the teaching mathematics, to make it as comprehensible and entertaining as possible. In addition to these components, the questionnaire also aimed to collect data on how the use of ICT in teaching mathematics increases cooperation, creativity and all other components that affect students' motivation. Another goal of the questionnaire was to collect the opinion of the students about the characteristics that a lesson should have, in order the students to participates there with pleasure.

The questionnaires data reveal positive results (Table 2), obtained during the experiments. They are a product of a well-thought-out combination of learning activities developed with the help of ICT tools and perfect planning of teachers' work.

Table 2. The impact of ICT tools on some of the elements that motivate students to learn mathematics.

Using ICT tools in teaching math	Not at all (1)	Not really (2)	Unde-cided (3)	Some what(4)	Very much (5)	Mean
Increases the desire to learn mathematics	4	21	18	95	78	4.0
Makes math an easier subject to understand	5	24	15	86	85	4.0
Makes math more fun	2	18	13	98	85	4.1
Strengthens cooperation between students	8	22	25	75	86	4.0
Increases creativity and helps the imagination	2	17	21	85	91	4.1
Increases students' self-confidence and self-esteem	7	19	24	71	95	4.1
Illustrates the connection that mathematics has with the world around us	3	12	23	103	65	3.9

Some of the activities that influenced the achievement of these positive results, both in increasing their intellectual performance in a personalized way and the positive attitudes towards the learning process as a whole, were:

1. Pre-creation of a personal profile of students' learning by delving into the characteristics, abilities, strengths and weaknesses of each of them.
2. Continuous reference in PPL, as well as good knowledge of students' learning modalities based on their strengths and weaknesses, to personalize learning while encouraging students' desire to learn mathematics according to their potential.

To be successful in the process of motivation, the math teacher should offer to the students:

1. The figure of the professional passionate in the learning process.
2. Lessons that are creative and always bring new situations away from the routine, with plans and activities that students have clear. They should be such that they are always amazed at the creativity that supports them as well as the instruments used to achieve the goal.

3. Active teaching methodology so that they feel involved in each stage of learning and do so willingly.
4. Positive social situation enabling collaborative learning techniques.
5. A friendly classroom environment where they want to be welcomed creates the conditions for them to feel valued and involved.
6. Clear panoramas on the connection that the mathematical concept has with the real world.
7. ICT tools that ambitiously support all of the above.

CONCLUSIONS, DISCUSSIONS AND FURTHER WORK

The thesis leads to concrete conclusions and recommendations, starting from the design, implementation, and transparency of the implementation of educational policies. It discusses the function of teaching and suggests continuous trainings of teachers to amplify personalized teaching of mathematics with the right ICT tools.

In this chapter are made some recommendations addressed to the faculties that prepare mathematics teachers, in addition to the ambitious development of their digital competencies, to renew the subject curriculum "Didactic tools in teaching mathematics", with software, ed-tech didactic games, for the teaching of mathematics. For older teachers, policies are implemented that enable their continuous training on the use of ICT tools in teaching.

The positive energy of the students during the teaching of mathematics, as well as their commitment to learning, is in sync with the commitment of the teachers and their enthusiasm.

Increasing students' motivation to engage in mathematics means educating students that:

- Have a clear purpose for which they learn mathematics and for this purpose, they also recognize the benefits that come from it.
- Believe in their abilities.
- Are creative and make constant efforts to develop their creativity.
- Are engaged in every moment of the learning process and beyond.
- Are collaborators, to research until a mathematical result or conclusion is drawn.
- Challenge themself and their friends.
- Are curious to find and interpret different solutions to situations from reality.
- Have developed self-esteem.

Discussions arise around the questions *Are the models for personalizing teaching of mathematics appropriate for all over the schools in Albania?* and *Would the nationally spread teachers' training on personalization of teaching/learning mathematics will lead to modernization of school mathematical education by smooth transfer from content-oriented to competency-oriented teaching/learning?*

Both of the questions provide ideas for further research, in collaboration with the University of Elbassan and the Ministry of education for organization of country large teachers' trainings and further pedagogical experiments.

AUTHOR'S CONRIBUTIONS

1. SCIENTIFIC AND APPLIED CONTRIBUTIONS

Scientific contributions

Personalized learning in mathematics is a modern educational approach, based on the strengths, skills and competencies of students, on the needs and weaknesses of students, supported by the opportunities, techniques, methods, and ICT tools, offered to students for their progress, with self-esteem and motivation. It is seen as a very subtle process that goes beyond differentiated learning, which is based on the needs of students, and beyond individualization, which is based on their pace.

Through this PhD thesis, personalized teaching in mathematics is addressed from a modern perspective, based on the support that ICT offers for personalizing mathematics teaching.

The scientific contributions that come from this dissertation are:

1. A detailed analysis has been made of the parallel evolutions that mathematicians and ICT thinkers have known, as well as the mutual influence they have had on each other.
2. The compatibility of the infrastructure with the regulatory framework for the competencies of teachers in Albania has been investigated, and it has been analyzed how close they are to the ICT competence framework of UNESCO for teachers.
3. An analysis has been made on the evolution and challenges of ICT in Albania as well as the policies of the Albanian government to implement ICT in the field of education.
4. The approaches of the regulatory framework to the mathematics curriculum based on competencies in Albania were analyzed, as well as the modest

changes that came from its implementation, in the results of Albanian students in PISA.

5. A systematic review of personalized teaching in mathematics was done. They are extracted the main teaching methods for the personalized tutoring course in mathematics.
6. The four components of personalized learning have been extensively discussed, explaining their characteristics with examples. It is analyzed the role that personalized learning plays in the mathematical form of students in lower secondary education.
7. A national questionnaire was designed and developed to investigate the attitude of Albanian mathematics teachers towards the support of ICT to personalize the teaching and learning of mathematics, focusing on:
   - Personal perception of the use of ICT in teaching/learning mathematics.
   - Teachers' interest in being trained in the use of ICT in teaching/learning to support personalized learning in mathematics.
   - Personal experiences with the use of ICT in teaching.
   - Difficulties encountered by teachers in their daily life, to use ICT to personalize the teaching of mathematics.
8. Semi-structured interviews were conducted with mathematics teachers. The interview aimed to investigate if the difficulties of mathematics teachers at work are related to:
   - the mathematics curriculum
   - with the quality of textbooks
   - with students' interest in mathematics
   - with the difficulties, they have to adapt to the rapid ICT developments
   - with the lack of training.
9. A detailed analysis of learning styles, accompanied by illustrations and examples from the mathematical context is followed by a series of advice that mathematics teachers should follow to personalize mathematics learning.
10. The entire process of personalization of learning mathematics is seen as a complex process related to teaching strategies, learning styles, and application of digital technology in learning mathematics and is illustrated with the "Pyramid" of personalized learning" (Figure 33) which expresses its connection with other components.
11. A methodology has been developed for training the teachers for the personalization of mathematical education with the support of ICT. It is equipped with relevant assessment teaching materials. The study provides:

- A practical model of using a SmartBoard in personalized mathematics teaching.
- A model used the GeoGebra software for handling the concept of function in the eighth grade.
- A model of using the application Kahoot!, to develop computer and critical thinking supported by mathematical problems that develop logic and rational thinking.

All the models brought for the developed experiments are supported by detailed plans according to the student's level as well as authentic mathematical problems for the identification of gifted and talented students.

12. A questionnaire was designed and developed for the students who were subjected to the experiment, which investigated the frequency of using ICT tools to develop different activities related to the teaching of mathematics in their schools. The questionnaire collected data on how the support of ICT tools in teaching mathematics increases cooperation, creativity and all other components that affect motivation. Another aspect that was investigated was the characteristics that a lesson should have, which students would be happy to attend.

Scientific-Applied contributions

Some of the models or templates which are scientifically justified and which can be especially applied in the field of mathematical education can be mentioned as follows:

1. Recommendations for educational policies in Albania to intervene in the direction of the implementation of ICT in education, where the three main directions where this intervention should be made are defined.
2. A list of important tasks that must be completed by the mathematics teacher to personalize the lesson has been made. The list contains tasks that the teacher fulfils and performs these activities: recognizes, chooses, prevents, directs, encourages, and creates.
3. A questionnaire was designed to investigate the learning styles of mathematics for students.
4. The questionnaire designed to investigate the access to technology that mathematics teachers have in Albania can be used to investigate the situation at a later time.
5. The results of the analysis of this investigation and the relevant recommendations are to be used in research of the same nature.

6. Training resources on learning styles and the role technology plays in supporting them in personalized learning.
7. Recommendations for education policymakers regarding teacher training to improve digital competencies
8. Detailed thematic plan on the concept of functions in the eighth grade, together with exercise models and the key mathematical competencies they develop.
9. Tests (pre-test and post-test) were specially designed to investigate the performance of students before and after the experiment, together with the evaluation table.
10. Logical questions for testing students from grades 5-9, in the application Kahoot!
11. Lists of authentic problems according to different levels of students are offered to teachers as a guide to guide new teachers to select different problem situations depending on the key competencies that each problem situation develops.
12. Questionnaire to measure the degree of motivation of the students, who were subjected to the experiments, as well as the results of the analysis of the collected data.

Mathematics teachers in Albania are very interested in training in the field of active teaching as well as in the support that educational technology offers to personalize teaching. Likewise, the professional networks of mathematics teachers conduct continuous training in relation to active teaching methodology. The teachers who take part in the training can train the teachers in their schools thus increasing the number of trained teachers. On the other hand, this model could serve teacher training agencies in Albania to provide personalized training for students in mathematics, and not only, supported by educational technology.

2. LIST OF AUTHOR'S PUBLICATIONS, RELATED TO THE TOPIC OF THE PHD THESIS

- *D. Starja,* **Personalized Teaching of Mathematics through ICT and the Personal Perception of Teachers of Using ICT in the Learning Process,** Proceedings of EDULEARN21 Conference, Publisher: IATED Academy, 2021, pages:5973-5979, ISSN (online):2340-1117, ISBN:978-84-09-31267-2, doi:doi.org/10.21125/edulearn.2021
- D. Starja, **The Impact of Learning Games on the Approach of Secondary Grade Students Towards the Subject of Mathematics and the Development of their Computational Thinking,** Proceedings of EDULEARN21 Conference, Publisher: IATED Academy, 2021, ISSN

(online):2340-1117, ISBN:978-84-09-31267-2, doi:doi.org/10.21125/edulearn.2021

- D. Starja, N. Nikolova, **From Pencil and Paper to ICT in Mathematics Teaching. An Overview of the Role of ICT in Mathematics Teaching in ALBANIA**, EDULEARN20 Proceedings, 2020, pages:2635-2644, ISBN:978-84-09-17979-4
- Diana Starja, Nikolina Nikolova, Bederiana Shyti, **Personalized Learning in Math, through Problem-Solving, and the Use of ICT, Education and New Developments 2020**, editor/s: Mafalda Carmo, World Institute for Advanced Research and Science (WIARS), Portugal, Publisher:inScience Press, 2020, pages:304-308, ISSN (print): 2184-044X, ISSN (online): 2184-1489, ISBN: 978-989-54815-2-1
- D. Starja, B. Shyti, N. Nikolova, **The Role of ICT in Improving Problem-Solving in Teaching Mathematics**, EDULEARN20 Proceedings, Publisher: IATED Academy, 2020, pages:2651-2659, ISBN: 978-84-09-17979-4, Ref, PhD
- D. Starja, N. Nikolova, **Importance of Logical-Mathematical Algorithms In School Mathematics**, EDULEARN19 Proceedings, editor/s: L. Gómez Chova, A. López Martínez, I. Candel Torres, Publisher: IATED Academy, 2019, pages:4482-4489, ISSN (print):2340-1117, ISSN (online):2340-1117, ISBN:978-84-09-12031-4, doi:10.21125/edulearn.2019.1124

3. DECLARATION OF ORIGINALITY OF THE RESULTS

I declare that the present dissertation contains original results obtained in my research with the support and assistance of my scientific advisers. The results obtained, described and/or published by other scholars are duly and in detail cited in the bibliography.

This dissertation is not applied to obtaining a scientific degree in another higher school, university or scientific institute.

Signature:

(Diana Starja)

ACKNOWLEDGMENTS

With deep gratitude and my highest consideration, I want to make these thanks:

Assoc. Professor Dr Nikolina Nikolova, who with her professionalism in the scientific aspect has always been ready to guide me, help, suggest and support this work, as well as for the human dimension and the values it conveys.

Assoc. Professor Dr Bederiana Shyti, with whom I have always found professional and humane support, believes in me and encourages me to carry out this work.

I thank all the professors of the **Department of Education in Mathematics** and Informatics, Faculty of Mathematics and Informatics at the University of Sofia, who showed me a model of how human beings should be related to professionalism in the people who train educators.

I thank the director of the non-public school "Imelda Lambertini" in Elbasan, **Mrs Kriselda Pepa**, for the support and provision of the technological base of her school for the realization of teacher training.

I thank the president of the professional network of mathematics teachers in Elbasan, **Mrs Arjana Shella**, who enabled the meeting with the mathematics teachers to discuss the issues of personalized teaching in mathematics through ICT, the organization of their training and the granting of permission for conducted her school experiment.

I thank the director of the school "Vinçens Prendushi" in Durres, **Mimoza Ismailaj**, for the support for the experiment in her school.

I thank teachers **Ermonela** and **Fatbardha** for their support and cooperation in conducting the experiments.

I thank all the **teachers** who found the time to complete the questionnaire, all the **students** who underwent the experiment as well as their parents who believed in advance in the good result that the experiment could have.

I also thank all the students who underwent the experiment, for their correctness, kindness, and motivated behavior throughout the experiment.

I thank my family who during this time has lost my attention, as a good part of the time I had to deal with my doctoral thesis.