REVIEW

under the procedure for the acquisition of the educational and scientific degree "Doctor"
by candidate *Diana Starja*,
of the PhD Thesis entitled:
"Personalization of secondary school mathematics education through the use of modern information technologies",

In the Scientific field: **1. Pedagogical Sciences,**
Professional field: **1.3 Pedagogy of learning in Mathematics**
Doctoral program "Teaching Methodology of Mathematics and Informatics",
Department "Education in Mathematics and Informatics",
Faculty of Mathematics and Informatics (FMI),
Sofia University "St. Kliment Ohridski"(SU),

The review has been prepared by: **Professor Dr Llukan Puka, University of Tirana, Faculty of Natural Sciences, Department of Applied Mathematics, Tirana, Albania,** as a member of the scientific jury for the defence of this PhD thesis according to Order № RD 38-669/ December 23, 2022 of the Rector of the Sofia University.

1. General characteristics of the dissertation thesis and the presented materials

The PhD thesis consists of 241 pages, including the main text, 5 appendices and the list of references. The main text is organized in **six Chapters**, the **Introduction** and **Conclusion**, the **Discussion** and **Further work**. The last part, **Appendices**, is composed of five subjects related to questionnaires or other questions. It contains 55 figures and 16 tables. The literature uses sources, mostly in the English language and some of them, in the Albanian language. Around 37% of sources have been published over the past five years (from 2017 to 2022), indicating knowing the current state of the field. The used literature is cited appropriately in the text of the dissertation.

Relevance of the problem

This study's research concerns the impact of personalizing secondary school mathematics education through the use of information and communication technologies, combining individual student interests with new technologies capacities.

It is known and accepted the important role of mathematics in developing critical, analytical and abstract thinking skills and at the same time for everyday life decisions. Also, its role in developing creativity and fostering a sense of aesthetics is undeniable.

Although there is no doubt about the role of mathematics in scientific and personal life, mathematical education faces serious challenges in motivating students to learn math. Many factors influence students' achievements and their functional mathematical literacy. Are known and discussed many times the relevant results of PISA and TIMSS international studies related to these factors. Educators try to develop new ideas, methods, technics to contribute to better mathematics learning and teaching methodologies fields.

The idea of individualizing mathematical education is an old and permanent idea in school mathematics teaching and learning, not new. Meeting the educational needs of the individual student has long been a concern of teachers and also a study subject for educators. Personalizing

instruction may be important for mathematics learning. In particular, it can enhance interest and motivation, which are important factors in teaching and learning.

The 21 century offers new perspectives in personalizing mathematical education through the use of information and communication technologies (ICT). The rapid growth of ICT has received relevant attention in mathematics education under its capability to provide innovative teaching and learning environments: technics, methods, and methodologies. On one side, teachers are required to integrate ICT into their teaching to override traditional methods with modern tools and facilities. On another side, students use these in their everyday life such technologies. How to include this use for the benefit of a better mathematical education?

Of course, the use of ICT cannot be confined to computers and internet provision, or an iPhone or a Smartphone use. It is ought to be supported by pedagogic learning activities. The education system in general, in mathematics in particular, should surpass the lack of knowledge to integrate ICT tools, the modest availability of resources, and insufficient teacher training facilities.

Given those actual and strategic imperatives, the Diana Starja thesis "Personalization of secondary school mathematics education through the use of modern information technologies" examines the situation, develops some theoretical and practical problems related to the subject and proposes a model for how to improve the effectiveness of personalized mathematics teaching/learning through ICTs. It aims to highlight some optimistic cases for the use of ICT in teaching mathematics, based on continuous training of teachers on the use of educational technological platforms, as well as other components of the multidimensional teaching process.

In particular, the actual Albanian situation is considered in this perspective: The technological (ICT) provision of Albanian schools as a tool to support the personalization of teaching/learning in general and mathematics in particular; the technological (ICT) background of a mathematics teacher, their formation and preparation on the subject; students in high schools in Albania.

2. Short CV and personal impressions of the candidate

Diana Starja graduated in Mathematic Sciences, Teacher of Mathematics, Faculty of Natural Sciences, University "Aleksandër Xhuvani" Elbasan in 1993 and graduated with a Master of Science in "Applied Mathematics" in "Aleksandër Xhuvani" University, Elbasan in 2013. She has worked at the University of Elbasan as, a part-time lecturer, since 2013, where she teaches subjects related to the methodology of teaching mathematics and the preparation of didactic tools for teaching mathematics.

Diana has 30 years of experience as a mathematics teacher, and for 18 years she has been the co-author of secondary school mathematics textbooks used in Albania, which include student books, workbooks, teachers' guides, differentiated exercises for talented and gifted students, a total of 54 texts books. During this long professional career, she participated in many training programs organized by the Ministry of Education, in Albania, or by other regional or other institutions

This fact shows a good recognition of the changes that the mathematics curriculum has undergone in the last 30 years in Albania, as well as the changes that the teaching of mathematics has undergone during these years. She was enrolled in the doctoral program "Teaching methodology of Mathematics and Informatics" at the University of Sofia in April 2019, with scientific advisers Prof. Dr Nikolina Nikolova and Prof. Dr Bederiana Shyti. Diana is in the process of defense of her PhD Thesis.

In this program, she worked in connection with personalized mathematics lessons through ICT in secondary school. In her scientific works supporting her doctoral thesis, personalized learning is seen as a process that has changed not only the pace of student learning but also the time and place of learning, keeping students focused on the finding of rich, external resources supported by ICT tools, to create new ways to learn. She sees personalized learning as a complex process that requires, first of all, a coordination of the work and tasks of all interested parties, for them to first understand the essence of personalized learning and then to strictly implement the tasks according to the role has personalized learning and all of this is reflected in the thesis of the doctorate.

For personalized learning in a way and for mathematics in particular, as a phenomenon that is being sought day by day, there are no previous studies in Albania.

I meet Diana during my visits to "Aleksandër Xhuvani" University in the Mathematics Department of this University where I have been invited to Professor, for many years. I found that she is a very active person in the field of learning and teaching mathematics in school, with a large variety of interests especially in training in the field of information and communication technology and innovation in teaching mathematics, active also in learning and teaching methodologies in mathematics and in the studies that have to do with the student's learning style, as well as the support provided by ICT in their identification and support.

3. Content analysis of the scientific and applied achievements of the candidate, contained in the presented PhD thesis and the publications to it, included in the procedure

In the first part of her thesis, the **Introduction**, the Candidate represents her motivation for choosing the study research problem. The author refers to many references related to the personalization idea of teaching and learning mathematics. She develops in this part the necessity to adapt the teaching to a new environment, where the ICTs tools are present and also, the general characteristics for a new education. The first of these characteristics is personalized learning. In this context implementing ICT in teaching usually increases the opportunities for a better math lesson. "... Technology is not just a tool. It can give students a voice they may not have had before."

The lines and arguments for a model of personalized teaching supported by ICT are presented in this part. The idea that the process requires a deep understanding of the skills, needs, and talents of the students combined with many other factors, and the continuously updated implementation of educational technology innovations for personalization of teaching and learning math, is accentuated. The proposed model develops successful cases for the use of ICT in teaching mathematics. In particular, it is noted that the teachers' training should be considered a very serious mission for all actors dealing with educational policies in Albania.

The **Introduction** presents detailed information concerning the Study Object and Subject, Research Questions and Hypothesis, Objectives and Tasks, and Research Methods and Tools. Also, here are presented the Structure and the content of the PhD Thesis, general lines for each of the Chapters, the Conclusions, and the Appendixes.

Chapter 1, Overview of the role of ICT tools in teaching mathematics. Approaches to their applications in the Albanian context have two parts. In the first part a systematic analysis of the evolution of the mathematics learning process, from pencil and paper teaching to modern mathematics teaching, is done. 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.

Section 1, the role of ICTs in mathematics education, is an overview of the situation, ideas, points of view, papers, facts, documents and materials on the subject. The general idea of a declining situation in learning mathematics is noted. Also, the role played by mathematical software, by ICT tools in general, is presented and analyzed from different points of view and different opinions are presented. For the successful integration of ICT, the role of the teacher is critical, because it is the teacher who decides when, where, how, and who will use ICT.

In **section 2, An overview of the development of trinôma: the human mind-mathematics-computer**, the author examines the problem of relations between these three components throughout the centuries; the difficulties and the ways to make mathematics teaching attractive have been the focus of teachers of all times. Regardless of the various methods, the introduction of ICT into the process of teaching mathematics is considered a new opportunity to raise the success of the teaching and learning mathematics process. The problem is how to implement ICT in this process.

Besides the need and the goodwill to make this integration, the process represents great challenges, different: lack of access to technology to the entire population, lack of special programs in the curricula of universities, and teachers' lack of ability to use technology effectively in classrooms.

Section 3, ICT implementation in teaching and learning mathematics, is composed of **three parts:** a *Historical overview of the ICT implementation in teaching and learning mathematics*, the *Benefits provided by ICTs tools in teaching mathematics* and the *most common uses of ICT and computers in general in teaching and learning mathematics*.

From Logo as an educational programming language (1967), followed by programming period (1970-1980), computer-based training (1980-1990) and multimedia, WWW, CD-ROMs, E-learning (1990-2000), to ICT (2000 -), is a short but very rich period of development: ICTs changed the World of education. A list of benefits to improve the teaching and learning of mathematics is presented briefly (section 3.2), followed by a description of the capacities of the most common software in mathematics education (section 3.3).

The focus of **section 4, ICT development in Albania: policies and strategy**, is an analysis of the Albanian situation on the subject and the efforts done by Institutions in Albania to follow the World ICT development and to use it for social and economic development. First **subsection 4.1**, is a historical overview, the **subsection 4.2**, represents the National policy and strategy for the development of ICT in education in Albania.

Subsection 4.3 is an Overview of competency-based learning in mathematics in Albania. The author analyzes the Curricula Framework of the Republic of Albania, making in evidence two most important elements: Competence-based learning and student-centred learning. Recommendation for improving in perspective of European Recommendations for lifelong learning (in mathematics) is done. The analysis is combined with the PISA results of Albanian students during the period 2000-2018.

In **section 5, Conclusions**, the final results of the analysis are presented. ICT tools are strongly influencing education as a whole, but especially in mathematics in particular. The benefits are undoubted. Regarding the current context in Albania, state policies have been and continue to be very ambitious regarding the implementation of ICT in teaching. This is reflected both in the curriculum frameworks of the mathematics curricula and in the National Strategies for the Development of Education in general. But, on the other hand, it is imperative the intervention in this field.

Chapter 2, Personalized learning in mathematics, is organized into **three sections**, and one of them shows the **Conclusions**.

As the title shows, the chapter concerns the definition and characteristics of personalized learning. This notion is explained and analyzed in different ways.

In the **first section, personalized learning components**, various definitions are analyzed, in general, and their significance in mathematics. Four components of personalized learning are presented and analyzed: Reflecting on students and setting their goals; Targeted instructions; Flexible paths and pace; Collaboration and creativity.

In the **second section, Impacts of personalized learning through ICTs tools on Mathematics education**, goals of learning math are presented.

The chapter is closed with the **conclusions. First**, ICTs tools in teaching mathematics are a necessity in the digital age in which we live. **Second**, the implementation of ICTs tools in mathematics teaching is multifunctional.

Chapter 3, Use of ICT in the teaching of Mathematics in Albania: state of affairs, is a quantitative and qualitative analysis, based on a questionnaire. The chapter analyzes the results of the questionnaire on the subject (data collection, findings, interpretations), and presents the results of focus group interviews regarding their experiences in personalizing mathematics teaching. The

Questionnaire is intended to survey the real situation in Albania: the existing ICTs tools, and digital competencies of teachers for personalized teaching and learning in mathematics.

The **first section** explains the methodology (instruments and data collection); the **second section** presents and analyzes data found (Socio-demographic information and professional context, Personal perception of the use of ICT in teaching mathematics; Teachers' interest in being trained in the use of ICT in teaching mathematics; Personal experience with the use of ICT in the classroom; Teachers' opinions about the factors, that affect the difficulties they have in using ICT in teaching mathematics)

This second section is a qualitative analysis of interviews organized with mathematics teachers regarding personalized learning and the role that ICT play in its realization.

The results of the questionnaire, in **Conclusion**, make evidence of the need for training as well as the need for better access to ICTs tools. From the analysis, it is clear that school capacities on ITC tools are minimal. Teachers (and students) have technological devices in use in everyday life, such as mobile phones, laptops, or personal computers, but only through them can they not properly carry out an entire process such as active teaching through technology. Half of them use technology rarely or not at all in teaching.

Chapter 4, Training teachers to provide personalized mathematics education supported by ICT tools, develops the importance of training for personalized mathematics teaching and learning. The teacher has a key role in this activity.

The chapter is organized into two parts. In the **first part,** the author analyzes the characteristics of learning styles and their role in the teaching of mathematics; the next question analyzed is the inclusion of ICT as a new style characteristic in teaching and learning; finally, is considered the tryptic teaching strategy, learning style and ICTs tools for personalized teaching of mathematics.

In the **second part**, the ideas are analyzed and developed for the case of Albania situation. After presenting the situation, practical training is realized in a district of Albania, which purpose was to provide a model for teacher training based on aspects of teaching student-centred learning styles, supported by ICT tools to personalize the teaching of mathematics. In her thesis, Diana Starja presents all the model steps and results: the purpose of training, objectives, duration and topics, methodology, and results. In the end, a list with **conclusions and recommendations** for authorities in Albania is presented.

Chapter 5, concerns the **Validation of teachers' training on personalized mathematics teaching, supported by ICT**. Following the description and the results presented in **Chapter 4**, this chapter presents **three experiments** regarding personalized teaching in mathematics, organized in three schools in two districts of Albania with teachers after finishing the training.

The **first experiment**, "Personalized teaching and learning mathematics through problem-solving, supported by SmartBoard", lasted 8 weeks (34 teaching hours of which 32 teaching hours and 60 minutes for the quarterly test).

The second experiment on "The efficiency of dynamic GeoGebra software, in giving differentiated instructions based on student levels, on treatment concept of functions in the eighth grade", lasted 8 teaching hours and the study population was the eighth-grade students with sampling, 3 eighth grade of this school (experimental group) and 3 eighth grade (control group).

The third experiment "The impact of learning games on the approach of secondary students towards the subject of mathematics and the development of their computational thinking", lasted 8 weeks and the students taken in the study were the students of 5 classes (Grade 5, 6, 7, 8, 9) with a total of 150 students of the secondary school.

In the **first experiment**, the author explains the motivation, followed by a brief overview of the benefits of Smartboard in teaching mathematics; after, she develops the problem-solving as a key competence for learning mathematics and an important personalization method and **why** problem-solving chosen to see the benefits of teaching math through SmartBoard. A meticulous description

of the experiment is done: characteristics of the study and the results obtained from it, teaching/learning design, experimental topics, personalized tests based on student levels, learning / teaching design implementation, results obtained and conclusions.

In developing the content of the **second experiment**, the author explains briefly why GeoGebra is selected and gives an overview (with a large list of references) on the role of this software in teaching/learning mathematics. As in the first experiment, a careful description of the second experiment follows. The experiment is a case study on the efficiency of dynamic GeoGebra software, in giving differentiated instructions based on student levels, on treatment concept of functions, in eighth grade.

In the **third experiment**, the study considers the role that learning games play in the development of logical and mathematical thinking. As in the two other experiments, the author, first, gives a brief overview and explains computational thinking in mathematics. The case study follows. It investigates the effect of learning games on the development of logical, critical, and computational thinking in students of grades 5-9 in a secondary school.

Kahoot!, a game-based learning platform, is chosen for the needs of the experiment. The study was conducted one hour every week, during the 12 weeks of the second quarter of the school year 2020 – 2021 with students in grades 5. – 9, (150 students). The type of experiment was controlled. The experimental result, together with the conclusions are presented.

Chapter 6, Influence of ICT-supported personalized learning mathematics on the motivation to learn mathematics, is a review and analysis of the results of the questionnaire which aims to make evidence of the reflection of the teachers and the students to the use of ICT tools in teaching and learning after that the three experiments has finished. The target population was the students who underwent the experiment, i.e. 216 students from the three schools where the experiments were applied.

Approaching the problem

The subject of this research thesis is the *Personalization of secondary school mathematics education through the use of modern information technologies with a focus on the Albanian situation.*

During the study, the author tries to develop responses to **three questions**:

- 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?
- How important is the continuous training of teachers in terms of learning modalities and support of ICTs tools, for active contemporary teaching in mathematics?
- Is the personalization of math learning through ICT increasing students' performance, as well as their motivation and self-confidence to deal with math?

Related to them, she considers **four hypotheses**:

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

For this, the doctoral thesis is conceived according to the following structure.

First, in the introduction, the **author explains the relevance of the problem** and presents a review of the literature; this is followed by explaining the object and the subject of the thesis

research, research questions, hypothesis and the objectives of the study, **related to the situation in Albania**.

This is followed by CHAPTER 1, which is **an overview of the role of ICT tools in teaching mathematics, with a focus on the application in the Albanian context**. The first part of the chapter is dedicated to a systematic review of the literature on the role that ICT plays in personalizing mathematics learning; also, a systematic analysis of the evolution of the mathematics learning process is done. In the second part, the author describes a national review in terms of the regulatory framework and the school ICTs infrastructure in Albania.

The study continues with CHAPTER 2, **Personalized learning in mathematics**, where are presented the general aspects of personalized learning and to analyze 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. In conclusion, the **author proposes some instructions** on how the personalized math lesson can be accomplished and **which tasks** the teacher must accomplish.

Having this background, the author begins the analysis of the situation in Albania; this is the content of CHAPTER 3, **Use of ICT in teaching mathematics in Albania: state-of-affaire**. A questionnaire with some targets groups shed light on these issues: The ***types*** of ICT tools that teachers have at their disposal for teaching in the schools where they teach; their ***perception*** of the use of ICTs tools in mathematics learning; the ***interest*** they have in being trained in the use of ICTs tools in teaching; ***personal experiences*** with the use of ICTs tools in the classroom; ***difficulties encountered*** by mathematics teachers in Albania in using ICTs tools in teaching mathematics.

In CHAPTER 4, the author analyses questions related to the **training of the teachers to provide personalized mathematics education, supported by ICT tools**. She 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**. This is the first experiment as well as the first tentative to consider such questions in the Albanian environment.

CHAPTER 5 develops analyses and presents the results of training, in three experiments organized around three themes:

- "Personalized teaching and learning mathematics through problem-solving, supported by SmartBoard";
- "The efficiency of dynamic GeoGebra software, in giving differentiated instructions based on student levels, on treatment concept of functions in the eighth grade";
- "The impact of learning games on the approach of secondary students towards the subject of mathematics and the development of their computational thinking".

Developing the **first experiment**, she explains briefly the benefits of using **SmartBoard** by presenting a different point of view in literature, making in evidence three characteristics that transform the SmartBoard into an efficient pedagogical: divergent learning, interactive learning and joint thinking. Further, she explains the raisons of choosing the problem-solving to see the benefits of teaching math through SmartBoard.Characteristics of the study and the results obtained from it follow. I think, methodologically the experiment is very well organized, with clear objectives. The teaching/learning design describes the plan of activities with the experimental group as well the content of activities: targeted objectives to be observed, topic elaborated and actively developed.

An additional package of problems and exercises that supported the whole process in the experimentt was developed. I note that this package was implemented also as auxiliary material, for a supplementary source to the textbook "Mathematics 7, for Cambridge Secondary 1" by Patrick Kivlin, Sue Pemberton, and Paul Winters (Pemberton, et al., 2014).

Among the students of the experimental group, it was observed that differentiating the levels of the students, made them curious, growing the duration of their concentration growing as well as their interest: often students reviewed in small groups solution schemes or other learning materials stored on the SmartBoard. Also, the time the teacher had available was greater, as ready-made materials prepared at home could be downloaded directly to the desktop and could be presented on the classroom SmartBoard.

The experiment, shows, in both groups, control and experimental, that the personalization of the learning process, with traditional methodological tools or supported by the use of technology, **increases the average grade** of students in the 152 test, for the period. In the experimental group, this increase was + 0.44 greater, which shows that the use of SmartBoard, has affected the student performance

The **second experiment** considers the **GeoGebra software** as a tool for teaching mathematics in general and here for the treatment of **function concepts** in the eighth grade.

Here author, first, insists on the necessity of using this software by developing a brief review of opinions and results presented in the literature. Its success of it in teaching mathematics from the smallest ages was undoubtedly for understanding mathematics.

In this experiment, the author's idea is to show that digital support educational technology is another dimension of personalized teaching/learning to make maths learning efficient.

This experiment shows the benefits of using GeoGebra software for the study of **linear functions in the eighth grade of lower secondary education** in Albania.

In paragraph 2.3.1, she explains in detail the study methodology; the design and the aims. The experiment took care to test the students before and after the period of the experiment. Based on the pre-test, in both groups, a detailed plan is presented with a list of learning outcomes that should master by the students according to the level.

Table 13 shows some of the activities performed by students in the experimental group, based on their pace, needs and abilities. The experiment considers also talented students to see their reactions to the use of GeoGebra.

Paragraph 2.3.3.4 analyses the experiment results by a post-test. It is seen that in the experimental group, there are 41.6% of intermediate-level students (marks 7, 8), compared to 40% in the control group. At the same time, 40.2% of the students in the experimental group belong to the upper level (marks 9, 10), compared to 29.4 who are in the control group.

In a conclusion, at the end of the experiment, the author considers that the use of GeoGebra is useful for teaching and learning, quantitatively expressed by some indicators (mean, mode, median). But I think, most important are the **optimistic results** which are expressed qualitatively in the **student enthusiasm**, the **use of GeoGebra outside the hour class**, the **increasing collaboration** and the **knowledge in the ICT field**; the experiments shows also the benefits for the teachers: using GeoGebra software was an experience that professionally enhanced even the teacher, who during all this time was practiced in advance at home to bring out the best she could for the students.

The author insists and suggests at the same time also, the use of GeoGebra in all classes and topics, not only in geometry. At the same time, a balance is necessary between the use of technology and manual practice. Asa software, it is preferable that the student knows GeoGebra, maybe in computer science subjects in school.

The **third experiment** deals with the advantages of mathematics games. Students' use of ICT tools cannot be avoided, electronic games also, so, they can be offered alternatives that support the personalized learning process in mathematics. The general role of mathematical games is analysed, in particular, Kahoot! the platform is used to build an experiment which aims to see the possibilities and advantages of mathematical games, their role in student self-esteem **motivation**, collaboration, in strengthening **positive attitudes** towards learning mathematics, developing logical and critical

thinking, especially **computational thinking**, a question which later is formulated as **three hypotheses to be tested**.

The analysis begins with a brief overview of the role that learning games play in the development of logical and mathematical thinking in paragraph 3.2. A general description of Computational thinking in mathematics is done in paragraph 3.3.

The study investigates the effect of learning games on the development of logical, critical, and computational thinking in students of grades 5-9 in secondary school. The experiment tries to prove the benefits of math technological games (in this study, of Kahoot's appl.) in these areas.

Concerning the experiment methodology, it is noted that this experiment was designed and implemented by the author herself, in contrast to the first two, which were designed by her but implemented by teachers.

The experiment was conducted in **two phases**: *one*, **the preparatory** phase, which aims the development of logical and critical reasoning in solving problems and mathematical exercises, in parallel with the development of computational thinking; the experiment lasted 13 weeks, one hour with each class each week, in the period September – December 2020. The *second* phase experiment aims to show the positive impact of learning games on the attitude of the students toward the subject of mathematics and the development of their computational thinkingg.

The study was conducted one hour every week, during the 12 weeks, with students in grades 5. – 9 (150 students). The type of experiment was controlled: the students of the experimental group underwent weekly quizzes, to check the mathematical knowledge, obtained in a week with the Kahoot! application. The control group underwent the same quizzes with pencil and paper.

The author explains in detail how the experiment is implemented, the way that Kahoot! was used, and shows the questionnaires proposed to the student each week. Based on the topics, developed in each class, the students underwent the final test, which for the control group was conducted by pencil and paper, while for the experimental group was conducted via Kahoot! The results of the experiment are evaluated, and the author considers them, by right, "fantastic": 90% of the students had the same result or found his result increased by 1 mark (47% of them).

In her conclusions, Diana noted the success of the game in teaching mathematics.

This study can be a reference point for the process of personalized learning, as well as for the development of teacher training modules, with topics related to personalized learning. It is also, a new practice to personalize learning math through play, even on their mobile phones or from the computers they have at home.

CHAPTER 6, tries to explore and give a response to the **question**: **how much do math teachers manage to motivate their students and how much does technology influence to support this process of motivation and self-assessment?**

It is a conclusive question related to all problems, ideas and the experiments that author realised on the cadre of this dissertation.

The response was evaluated by a questionnaire, which target group was the population of **216 students** from the **three schools** where the experiments were applied, so the students who underwent the experiments.

The results show that students use relatively few ICT tools in mathematics (an average of 2,1 on a 5 Likert-scale), except when they are obliged (average 4,1), for e-communicating (e-mail, average of 4,5) or to follow tutorials (average 3,1).

But they are optimistic about the usefulness of ICT tools use on the motivation of learning mathematics. A list of some of the answers that most of the students provided to the question "Why do you learn math?" is shown, together with a list of the characteristics of a math lesson they would love to attend.

The results of this chapter, confirm the fourth hypothesis of the thesis that "The use of ICT in teaching mathematics, to personalize learning, brings higher results in students 'mathematical thinking and at the same time increases students' self-esteem and motivation "

The last part of the Diana thesis is a resume of Conclusions, Discussions and Further work. The material is organized into different sections, each section corresponds to one of the big problems developed in the study. Some of them, I found interesting, because not only make evidence of the strong role of ICT tools in personalized teaching and learning mathematics but at the same time can be used as a guide for the subject to the mathematics educators (example: *Table 17. Range of tasks to be completed by the math teacher as he/she personalizes the teaching and learning of mathematics*).

Also, the conclusions are the results of three experiments developed by her in the Albanian environments. Important are conclusions regarding the current Albanian context. She noted that, although the state policies have been and continue to be very ambitious regarding the implementation of ICT in teaching (reflected both in the curriculum frameworks of the mathematics curricula and in the National Strategies for the Development of Education in general), the current situation in Albania needs urgent intervention. And then she describes three lines of this intervention.

Section 6, suggests recommendations regarding teacher pieces of training in the field of digital competencies.

Section 7, is a resume of three experiments, on the use of SmartBoard, GeoGebra and Kahoot!. She notes that to have such positive results it is necessary to combine learning activities, developed with the support of ICT tools, with perfect planning of teachers' work.

In section 9, discussion and further work, Diana develops a very objective analysis organized into four parts: a summary of the **key findings** and **interpretations**, the **implications** of the study, limitations of the study and **rrecommendations** for practical implementation or further research.

I found it very informative, well-structured and presented the last part of the thesis, the author's contribution. This part is organized into two parts: one develops the scientific contribution of the thesis, and the second the scientific-applied contribution. This second part, in particular, can be a document for the institutions in Albania to consider the politics in mathematics teaching/learning fields and the use of ICT tools, for reflections, questions, and solutions.

As I am informed, this thesis is the first systematic and deep study in Albania related to ICT tools used in mathematics teaching, not only in mathematics. Those interested in this field, from different horizons, can find there many information or study problems for further works or other developments, for other studies.

Approbation of the results

The results were presented in 7 papers at international conferences, in 5 of which she was a co-author with scientific leaders with equal contributions, and in the other two, she was the sole author.

Except this, are three other papers, two papers are published in the scientific bulletin of the University of Elbasan, and another is a presentation at a conference (DIGI DAY) at the University of Gjilan in Kosovo.

I have read her works in Research Gate and they bring a clear view of personalized learning in mathematics supported by ICT, focusing mainly on problem-solving, learning games, and gifted and talented students.

The publications which form the base of the dissertation are 6 - one in Education and New Developments 2020, World Institute for Advanced Research and Science (WIARS), Portugal, as well as 5 others in EDULEARN's Conferences. Starja's results are relatively new and have no citations so far.

According to her ResearchGate profile, the statistics, on January 18, shows that she has 3,981 reads, 5,246 recommendations, research interest score is 1,066; Diana's Research Interest Score is higher than 93% of ResearchGate members. She has 353 full reads from R^G members.

In the Google Scholar Platform, I found 7 papers published, some of them have citations from 2019,

I think, the scientific works presented by Diana Starja, meet the minimum national requirements (under Art. 2b, para. 2 and 3 of ADASRB*) and respectively to the additional requirements of SofiaUniversity "St. KlimentOhridski" for acquiring the educational and scientific degree"Doctor"/scientific degree "Doctor of Science" in the scientific field and professional field of the procedure.

The references present reasoning for the relevance of the chosen topic and the author's contribution to solving important societal problems in the field of educational innovations.

The results presented by the candidate in the dissertation work and scientific works to it do not repeat such from previous procedures for acquiring a scientific title and academic position;

There is no plagiarism proven in the legally established order in the submitted dissertation work and scientific papers under this procedure.

4. Qualities of the abstract

Abstract is presented in Bulgarian and English (32 pages each) and fills requests for the preparation of such documents. Results from the dissertation and its contents are presented correctly.

5. Critical notes and recommendations

I do not have any important significant critical remarks about the work done by the author. I consider that is a serious and successful work on the subject of study chosen by her and the supervisors. The study done by this thesis, the experiences gained during the thesis preparation, and the research personal level are of considerable value for her profession and her career.

Some minor notes concern the redaction or technical layouts of the material. The thesis is very well written and has the correct organization. The content reflects in detail the cadre of the study work. Anyway, in some cases, the spaces between words or paragraphs, are not correct, and in some cases, figures are on the left not in the centre (justify) as it is in general the rule on the text; I found some errors in numbering also, example in paragraph 1.6.5 (p.151) we see a sous-paragraph 1.6.5.3 but not 1.6.5.1 or 1.6.5.2. Or, on p.210-211, the same numbers:

3. Limitations of the study

3. Recommendations for practical implementation or further research

In the list of references, I found also some incorrectness. So, the rule author, year, title, ...etc., which seems that is chosen by the author as a form of presentation, is not respected everywhere; and, also I found other incorrectness, the year of publishing twice, or only the name without an index for the surname, etc.

Example:

Integration of ICT in the Mathematics Classroom. **Jackson,**. 2017. 2017, Journal of Initial Teacher Inquiry, Vol. 3

Or,

Integration of ICT in Mathematical Understanding Using Modeling. **Hashem, and Arman,**. 2013. 2013, International Journal of Computer and Information Technology.

In general, a reference is presented as:

Jones, Martin A. 2010. Using ICT to develop abstraction. [book auth.] Jones Martin A. Proceedings of the British Congress for Mathematics Education. 2010

Sometimes the reference is not fully informative, and the bibliographic data (incl. author name and year of publishing) of some references are not indicated correctly / completely.

Example:

Re-examining cognitive tools: new developments, new perspectives, and new opportunities for educational technology research. Drew, 2019. 2, 2019, Vol. 35.

Also, there are no universal standard identifiers (such as ISBN, ISSN, DOI) listed in most of the reference sources. This is not the case for the list of author's publications at the end of the Thesis, where the information is complete.

Finally, this thesis develops a constructive list of recommendations: the interested can find their issues for their work.

The results confirm again the fact that the computer tool completes the means available to teachers and students to implement the different aspects of a real mathematical activity.

I would like to insist on two-three considerations (which of course, the author has treated):

First, I will suggest that the study results must be known by the Albanian institutions working in the education field (Government, etc., one resume has to be known and presented, a kind of guide for future work);

Second, I would insist on the necessity of teacher's education with the ICT tools use during the university preparation (curricula etc., actually sporadic, a revision of the curricula is really important).

The third suggestion concerns the attention to teacher licensing (necessity to improve it including the ICT knowledge) and teacher training during their professional activity (continuous training)

The last is the "technology" used, textbooks and software: the necessity to improve the textbooks having in mind the use of ICT and to propose appropriate software and solutions (use of Python is a new way).

I would like also to insist in the development of a similar study for all country, completed with other variables, having in mind better the geographical heterogeneity and including different level at school education.

6. Conclusion

Having become acquainted with the PhD thesis presented in the procedure and the accompanying scientific papers and based on the analysis of their importance and the scientific and applied contributions contained therein, **I confirm** that the presented PhD thesis and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the ADAS in the Republic of Bulgaria, the Rules for its Implementation and the corresponding Rules at the Sofia University "St. Kliment Ohridski" (FMI-SU) for acquisition by the candidate of educational and scientific degree "Doctor" in the Scientific field **1. Pedagogical Science**, Professional field **1.3 Pedagogy of learning in mathematics.**

In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, **I strongly recommend** the scientific jury to award **Diana Starja**, the educational and scientific degree "Doctor" in the Scientific field **1. Pedagogical Science**, Professional field **1.3 Pedagogy of learning in mathematics**.

Date: **Reviewer:**

January 31, 2023, **Llukan Puka**