REVIEW

under the procedure for acquisition of the educational and scientific degree **Philosophy Doctor** by the candidate **Mladen Georgiev Valkov,**
of the PhD Thesis entitled: Development of digital competence in mathematics education,
In the Scientific field: **1. Pedagogical Sciences**
Professional field: **1.3. Pedagogy of learning in …**
Doctoral program *Methodology of education in mathematics, informatics and information technologies*,
Department *Education in Mathematics and Informatics*,
*Institute of Mathematics and Informatics, Bulgarian Academy of Sciences***,**

The review has been prepared by: **Prof. Borislav Yordanov Lazarov, PhD,** Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
as a member of the scientific jury for the defense of this PhD thesis according to Order № 53 / 27.02.2024 г. of the Director of the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, and designated as a reviewer at the meeting of the Scientific Jury held on 11 March 2024.

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

The dissertation thesis meets the requirements of Art. 27 of the Regulations for the Implementation of the Law on the Development of the Academic Staff in the Republic of Bulgaria. The dissertation consists of 215 computer typed pages, which correspond to approximately the same number of standard typewritten pages. In this number, a Bibliography of 91 cited sources, of which 38 are in Bulgarian, the rest in English is included. There are 256 figures in the text, some of which are photographs, others are screenshots; various tables and charts of statistical observations directly related to the dissertation research are included.

The thesis is structured in an Introduction, three Chapters and a Conclusion, the content of which will be discussed in sections 3, 4 and 6 of this review. A list of the Candidate's publications is attached, as well as a list of scientific forums where research results have been reported.

The submitted documentation related to the defense is in accordance with the requirements of the Regulations for the terms and conditions for the acquisition of scientific degrees and for holding academic positions at the Institute of Mathematics and Informatics of the BAS. From this documentation, it is clear that the Candidate meets the minimum requirements, and in some respects repeatedly exceeds them – for example, with a required minimum of 40 credits under Section II (Reporting to Scientific Forums), he scores 304.

2. Personal data and Reviewer's impressions of the candidate

Mladen Valkov completed secondary education at the Shumen Mathematical High School, higher education at the FMI of SU "St. Kliment Ohridski", the master program *Applied Mathematics - Optimizations*. Everywhere with excellence. Subsequently, he was lecturer at the FMI of SU; he has held positions as a software engineer in international companies, in one of which he is currently employed.

The Candidate manifested his mathematical talent in early school years – he participated in many national and international competitions, where he won gold and silver medals. As a student, he continued his successful performances in university mathematics competitions. Mladen Valkov was twice awarded with the *Nikola Obreshkov academic price*. Currently, he brings his experience

aggregated in math competitions to the innovative *VIVA Math by Computer* competition. Participates fully in European projects.

Beyond the topic of the dissertation, Mladen Valkov has published results in calculus (together with Professor Nadezhda Ribarska). He has fluent English, also uses Russian and Chinese. Undoubtedly, the Candidate is a versatile young professional with bright prospects.

3. 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

We fully acknowledge the contributions described by the Candidate in the relevant part of the dissertation. Below we are going to follow the structure of the dissertation. Important note: we do not have an English version neither of the dissertation thesis nor of the abstract, so the terminology we use in this section could diverge with the author's one in English.

In the **Introduction**, the Candidate convincingly justifies why the topic stands on agenda, doing comprehensive analysis of Bulgarian and European documents on digitization of the economy, public structures and education. The purpose, object and subject of the dissertation research are precisely and clearly formulated. The hypothesis that "the use of the developed by the Candidate toolkit provides opportunities for the development of students' digital competence through mathematics education" is stated. The tasks that are set to achieve the goal and methods for solving them are described in details.

In **Chapter 1.** (Digital competence: theory and practices) a detailed overview of the status quo on issues of digital competence and its development in mathematics education is made. Strategic documents and specific studies are analyzed; examples of forming and upgrading digital skills and attitudes are given; the role of different tools and approaches is clarified. The three models of digital competence – of citizens, of users and in education – have been examined, specifying their application in mathematics education, and also for building various interdisciplinary connections. It is important to note that in the overview (which in itself has the qualities of a separate dissertation research) the Candidate does not limit himself to formal citation, but competently expresses his professional attitude, supported by examples from his practice and the activities of IMI.

In **Chapter 2.** (The *StruniMa* educational system as a tool for the development of digital competence in mathematics education) The candidate presents his author's product. It is beyond my competence to comment on the software architecture of the system. From didactic perspective, *StruniMa* implements methods of *learning by playing* and the experimental approach. This style is not new in mathematics education. Innovative are both the selection of mathematical topics (for example from combinatorial topology: *Board Covers, Graphs and Chains, Knots and Connections*) and the depth of their presentation (reaching the level of international mathematical competitions and contests). The examples unequivocally illustrate the multi-lateral mathematical culture of the Candidate and his skills to synthesize methodology and computer technologies into a unique didactic complex. Technically, *StruniMa* includes three components - *School*, *Learn* and *Duels*, which can be applied for different methodological decisions in the educational process. For example, the *School* component is suitable for synchronous distance learning through the *StruniMa classroom*. The system also has functional capabilities for research in mathematics education, for example to track the reflection of individual students or target groups.

In **Chapter 3.** (Pedagogical experiment), three experiments are presented, in the first of which activities are done with 5th grade students, in the second one – with 8th graders, in the third one – with 9th grade students, as well as with 5th and 6th graders. Key indicators for digital competence at the relevant educational stage are monitored, in each of which the application of the *StruniMa* system

leads to an increase in the level of digital competence and thereby confirming the research hypothesis. In parallel, the students' achievements in the mathematical topics underlying the experiments are monitored. In this chapter of the dissertation research, Mladen Valkov demonstrates an excellent mastery of the research tools applied in didactic experiments.

In the **Conclusion**, the Candidate makes a retrospective of what has been achieved in Bulgaria on the way to the digital transformation of education. Major achievements and problem areas are noted. The role of mathematics education in this process is emphasized. Mladen Valkov modestly notes how his system *StruniMa* could contribute to higher student achievements as a result of the digitization of education.

4. Approbation of the results

Separate results of the dissertation research are published in 4 articles, one of them is independent. Despite the relatively small number of articles, the Candidate has an impressive list of participation in scientific and applied forums – 13, of which 9 are independent. The articles are not cited yet, but that is normal having in mind that they are quite recent – three are from 2021, one is from 2022.

The scientific works meet the minimal national requirements (according to Article 2b, paragraphs 2 and 3 of the *Act on Development of the Academic Staff in the Republic of Bulgaria*) and, accordingly, the requirements of the Regulations of the Institute of Mathematics and Informatics - Bulgarian Academy of Sciences for the acquisition of the educational and scientific degree PhD in the scientific area and professional field of the procedure. No elements of plagiarism were noticed in the presented dissertation work and in the scientific works under this procedure.

5. Qualities of the abstract

The abstract was published on the website of the Institute of Mathematics and Informatics - Bulgarian Academy of Sciences on 13 March 2024. It meets the requirements and correctly presents the results and content of the dissertation work.

6. Critical notes and recommendations

Some minor inaccuracies can be easily corrected. It would be good to give a direct reference to the list of literature when citing individual sources (for example, "Digital transformation of Bulgaria for the period 2020-2030" on page 4). The use of "й" instead of "ѝ" should also be avoided (p. 8). It is recommended to replace the abbreviations AR and VR with the corresponding established terms in Bulgarian. A terminological inaccuracy is the use of 'projection' in the text around Figure 3.7 (normally projection preserves central symmetry) – perhaps 'perspective' is more appropriate. Moreover, rigid motions in three-dimensional space are not included in the middle school curriculum, and experiments with students, especially fifth graders, have unclear didactic dimensions.

Some results of the research could be of interest to the participants in the Spring Conferences of the Union of Mathematicians in Bulgaria, and in this regard, we recommend relevant independent publications to be prepared. We wish Mladen Valkov to carry out the research related to his observation that "when the students' achievements in mathematics are higher, the average grade in information technology is higher" (p. 176).

7. Conclusion

Having become acquainted with the PhD thesis presented in the procedure and the accompanying scientific papers and on the basis of 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 ***Act on Development of the Academic Staff in the Republic of Bulgaria***, the Rules for its Implementation and the corresponding Rules at the ***Regulations for the terms and conditions for the acquisition of scientific degrees and for holding academic positions at the Institute of Mathematics and Informatics - BAS*** for acquisition by the Candidate of educational and scientific degree **Philosophy Doctor** in the Scientific field 1. Pedagogical Sciences, Professional field 1.3. Pedagogy of learning in … .

Based on the above, I strongly recommend the scientific jury to award Mladen Georgiev Valkov, the educational and scientific degree **Philosophy Doctor** in the Scientific field 1. Pedagogical Sciences, Professional field 1.3. Pedagogy of learning in …

Date: 20 April 2024 Reviewer:

/ **Prof. Borislav Yordanov Lazarov, PhD,** /