

## REVIEW

by **Dr. Zhelyazka Dimitrova Raykova,**

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of a dissertation for awarding the educational and scientific degree "**doctor**"

by: **field of higher education** 1. Pedagogical sciences

**professional direction** 1.3. Pedagogy of training in ...

**doctoral program** "Teaching Methodology in Biology"

**Author: Kalina Emilova Ivanova**

**Topic: *Formation of practical knowledge and skills in students through STEM training (Biology and health education - 7th grade)***

**Research supervisor: *Assoc. Dr. Delka Vasileva Karagyozyova-Dilkova - PU "Paisii Hilendarski"***

### **1. General presentation of the procedure and the PhD student**

The materials presented by **the PhD student** Kalina Emilova Ivanova are in accordance with the requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria, as well as with Art. 36 (1) of the Regulations for the Development of the Academic Staff of PU "Paisii Hilendarski". The set of documents includes:

- a request to the Rector of PU to disclose a procedure for the defence of a dissertation work;
- CV in European format;
- protocol from the departmental council related to reporting the readiness to open the procedure and preliminary discussion of the dissertation work;
- statement by the scientific supervisor, Assoc. Dr. Delka Karagyozyova-Dilkova, regarding the readiness to defend the dissertation work;
- dissertation work;
- abstract;
- declaration of originality and authenticity of the attached documents;
- a certificate of fulfilment of the minimum national requirements for the **the PhD student's** scientific activity;
- a list of 5 scientific publications on the subject of the dissertation;
- copies of scientific publications.

The scientific jury for the dissertation defence procedure was selected and approved by Order No. RD-21-1417 dated 07/08/2024 of the Rector of Plovdiv University "Paisii Hilendarski" (PU) on the basis of Art. 4 of the Law on the Development of the Academic Staff of the Republic of Bulgaria (ZRASRB) and in accordance with Art. 2 (2), Art. 30 (3) of the Regulations for the implementation of the RSARB and Art. 37 (1) of the Regulations for RAS of PU "Paisii Hilendarski".

## **2. General description of the presented materials**

By order No. PD-21-1417 dated 07/08/2024 of the Rector of the Plovdiv University "Paisii Hilendarski" (PU), I have been appointed as a member of the scientific jury to ensure a procedure for the defence of a dissertation on the topic Formation of practical knowledge and skills of students through STEM training (Biology and Health Education - 7th grade) to acquire the educational and scientific degree PhD in the field of higher education 1. Pedagogical sciences, professional direction 1.3. Pedagogy of teaching in ..., PhD program "Methodology of teaching in biology". The author of the dissertation is Kalina Emilova Ivanova - a full-time PhD student at the Department of Botany and Biodiversity at the Faculty of Biology of the Polytechnic University with scientific supervisor Assoc. Prof. Dr. Delka Vasileva Karagyozova-Dilkova from the Paisiy Hilendarski Polytechnic University.

The set of paper materials presented by the doctoral student is in accordance with Article 36 (1) of the Rules for the Development of the Academic Staff of the PU, includes the following documents:

- a request to the Rector of the PU to disclose the procedure for the defence of a dissertation work;
- curriculum vitae in European format;
- protocol from the departmental council related to reporting the readiness to open the procedure and preliminary discussion of the dissertation work;
- dissertation work;
- abstract;
- statement by the scientific supervisor, Assoc. Dr. Delka Karagyozova-Dilkova, regarding the readiness to defend the dissertation work;
- declaration of originality and authenticity of the attached documents;
- a list of 5 scientific publications on the topic of the dissertation;
- copies of scientific publications;
- a certificate of fulfilment of the minimum national requirements for the doctoral student's scientific activity.

All provided documents have full textual content and comply with the requirements of the Regulations for the Implementation of the ZRASRB and Art. 37 (1) of the Regulations for RAS of PU "Paisii Hilendarski".

## **3. Brief biographical data for the doctoral student**

**The PhD student** Kalina Ivanova was born in 1975. She graduated with a major in "Biology and Chemistry", a master's degree at PU "Paisii Hilendarski". He worked as a biology and chemistry teacher from 1998 successively in several Plovdiv schools and later became a teacher and deputy director of educational affairs at Yane Sandanski Primary School, Plovdiv. The desire for continuous professional development of Kalina Ivanova can be seen from the large number (29 units) of completed postgraduate courses. They are in the field of STEM, ICT, modern educational technologies, educational issues and educational innovations. We can also judge her high professional achievements by the acquired 3rd degree of qualification steps in the field of management and innovations in educational organizations. Her activity as a teacher is also evidenced by her participation in 15 scientific conferences and work on 9 national programs and projects of the Ministry of Education and Culture. The fact that Mrs. Ivanova has a Google Certificate for level 2 and that she can work as a Google trainer leaves a very good impression on me. This is a strong evidence of her interest in modernizing science education at school.

Kalina Ivanova's entire work experience is related to studying biology and chemistry at school. This combined with her excellent training in the field of innovation in secondary education determines her very good preparation and experience to carry out this dissertation research.

#### **4. Actuality of the topic and appropriateness of the set goals and tasks**

Developments in the dissertation problem and extremely relevant, both for pedagogical theory and for educational practice. Globally, there is an increased focus on STEM education, which is based on technological and economic growth. In Bulgaria and at the European level, there is a clearly expressed policy to support STEM education in schools. Updating curricula and developing new models for STEM lessons is an important part of implementing these policies, with the goal of better preparing students for the future. Currently, the Ministry of education is actively working on three STEM projects, one of which is "Creation of methodology and resources for STEM education in a STEM environment".

In the introductory part, the PhD student well motivates the choice of topic, its relevance and significance, as well as the need to create a specific technology for preparing, planning and conducting quality STEM training, focused on forming practical knowledge in students when studying biology and health education in 7<sup>th</sup> grade. Certainly, the development of a system of STEM lessons, in connection with the upcoming training of teachers to work in STEM, is a current problem. The methodological model proposed in the dissertation research can be the framework by which these lessons are developed.

The presented topic is a dissertationable one, and up to this point in the Bulgarian methodical literature on natural sciences, ~~there~~ a similar independent study aimed at constructing and applying models of organizing and conducting STEM training has not been described. Therefore, the presented experimental research has its scientific and applied value for Bulgarian secondary education and for the methodology of teaching biology.

#### **5. Knowing the problem**

The theoretical overview is presented in the First Chapter, and basic research terms and concepts are extensively and qualitatively examined. Here, the characteristics, 21st century skills, frameworks, models and good practices of integrated STEM learning and its advantages,

benefits, challenges and limitations are described in depth. A sufficient number of classical and modern bibliographic sources (116 items) were skilfully used and a thorough interpretation of the concepts used was carried out. This shows the good awareness of the PhD student and her ability to creatively evaluate literary material.

## **6. Research methodology**

The research methodology covers the mandatory requirements for a dissertation work of a pedagogical nature. A clear research agenda is set out, described in Chapter Two, which is indicative of the depth and precision of the work. In this chapter, the aim, object, subject and research hypothesis are clearly formulated. The set tasks that frame the research are specific, subjected to the goal and spelled out unambiguously. The research methods used are traditional for such pedagogical research and include: theoretical: analysis of literary sources, good pedagogical practices; empirical: analysis of teaching content in biology and health education 7th grade, didactic experiment, testing, surveying, statistical methods for data processing and analysis. The PhD student has shown skills in the selection and scientific analysis of specialized literary sources, knowledge of a number of theoretical research methods and demonstrated their successful application. A detailed toolkit has been prepared for each empirical data collection method.

A system of criteria and indicators adapted to the relevant educational content was used to measure the results of the study. Based on the statistically appropriately processed results, conclusions were drawn, which are described in Chapter Three. The number of participants in the empirical study is sufficient (112 for the preliminary test, 92 and 98 respectively for the main and the final experiment, all from “Yane Sandanski” Elementary School, Plovdiv), which ensures sufficient representativeness.

The experiment itself is very thoroughly described and I consider this to be one of the strengths of the thesis. The applied complex methodology provides an opportunity for a reasoned answer to the posed research question, whether the constructed methodological model of STEM teaching in biology and health education in the 7th grade will increase the level of students' practical knowledge and skills in biology and health education, their motivation and of the development of 4C skills of the 21st century.

I highly appreciate Kalina Ivanova's ability to conduct precise pedagogical research, collect and process empirical data, formulate reasoned conclusions and describe all this in a clear and scientifically sound style.

## **7. Characterization and evaluation of the dissertation work**

The dissertation work is presented in an introduction, three chapters, a conclusion in which the conducted research activities and the contributions of the conducted experimental research, a list of used literature and 6 applications. The main text is laid out in 165 pages and evenly distributed between the chapters, and the appendices are presented in 57 pages. 116 sources are cited, of which 38 titles in Cyrillic, 78 titles in English and 6 Internet sites. The main text contains 63 figures and 58 tables, the list of which is presented at the end of the main text of the dissertation. The Appendix presents the research toolkit (the survey, the tests and the form for expert assessment) and some methodological developments and materials for STEM lessons and STEM projects.

**The introduction** presents the relevance and significance of STEM and STEM education and its place in state regulatory documents. In **Chapter One**, a theoretical analysis of the literature on the problem is made. Here, a brief historical overview of the development of the STEM concept is presented and each component of STEM is characterized. This is done thoroughly, clearly and graphically through the use of 5 figures and based on a sufficient number of properly cited literature sources. The various definitions of STEM and i-STEM formulated by 27 researchers in the field are systematically tabulated. Referring to their opinion, the PhD student made a thorough analysis of the various definitions and interrelationships, arguing her own judgment and herself formulated a working definition of STEM education in her own research. This speaks to the deep understanding of the research problem, conceptual clarity and ability to make terminological clarifications.

I very much appreciate this thorough examination of the conceptual apparatus related to STEM and STEM education.

In the context of the set tasks, the PhD student pays special attention to the 4 frameworks most widely cited in the literature for constructing STEM lessons (by Honey et al., "Learn STEM", 6E, STE(A)MIT - the first European integrated frame of reference). In the same chapter, educational models (learning by Design, 5EBSCS, 6ELearning by DeSign TM, PIRPOSAL) for STEM integration are examined, which guide Mrs. Ivanova in building her own model for organizing and conducting STEM education. As a very useful part of the research, I appreciate the described good pedagogical STEM practices with predominant scientific fields of physics, biology and chemistry. The issue of active strategies, approaches and methods in STEM education is also addressed here. A brief description of the most applicable methods is presented systematically in table 2, which shows the high professional competence of the doctoral student regarding the procedural side of STEM education. Within the same chapter, the skills of the 21st century are also described, the development of which is the main goal of STEM education. The reasoned description of the advantages and benefits of the implementation of STEM education, as well as the difficulties and limitations of i-STEM, is a logical conclusion of the content of Chapter One. Thus, the doctoral student demonstrates the ability to impartially consider a given scientific problem and the ability to evaluate different statements and positions.

**The second chapter** "Design of Pedagogical Research" contains a presentation of the research concept and its corresponding instrumentation. I highly appreciate the detailed and clear description of the methodology, methodology and technology of the empirical study. Here the aim, tasks, object, subject and research hypothesis are formulated. On the basis of a good knowledge of the normative documents, the choice of topics from the teaching content of biology for the 7th grade, included in the study, is justified. The analysis of the learning content in these topics is done in the focus of the research objective.

In this chapter, the PhD student presents the methodological model for implementing STEM education constructed in the course of the research. It is influenced by the BSCS 5E (Bybee et al., 2006; Bybee, 2009) and 6E Learning byDeSIGN™ (Barry, 2014) models for STEM integration. The activities of the teacher and the students during the conduct of STEM lessons are integrated into five phases, the detailed description of which is made graphically in Fig. 11 and systematized in Table 9. With this naming of the individual phases of the model, the abbreviation ME/POPO is obtained, which is assumed to be the model name. I very much

appreciate the proposed examples of concretization of the model in pedagogical practice of the study of biology in the 7th grade. I believe that the constructed methodological model for the implementation of STEM education, which is the aim of the study, is properly described, illustrated successfully and justified convincingly.

In this chapter, the PhD student described the course and stages of the conducted empirical research, the toolset, criteria and indicators for reporting the results of the experiment and the statistical methods for processing the results. All this has been done with a good balance of the content volume and with clarity in the speech, generated by the good scientific training of Mrs. Kalina Ivanova.

**The third chapter** entitled "Analysis of the results of the pedagogical experiment to study the qualities of the methodological model" includes the presentation, statistical processing and analysis of the empirical-experimental facts collected by the author. This chapter impresses with the breadth, comprehensiveness and detail of the presented results. The conclusions drawn after each analysis demonstrate the author's competence in interpreting statistical data. The results before and after the implementation of STEM training have been analysed in detail according to the created methodological model, using specified indicators to evaluate the acquired levels of knowledge and skills. The students' attitudes, motivations, degree of formation of the 4C skills were also assessed in detail according to previously developed criteria and indicators.

The interpretation of the results confirm the achievement of the learning objectives and the qualities of the proposed methodological model. All results unquestionably confirm the working hypothesis related to a positive assessment of STEM education on motivation and the formation of 4 C skills.

My high assessment of the quality of this part of the dissertation is based on the large volume of data collected, their analytical processing and their summary and interpretation. However, reading this part of the thesis took me a lot of time and more effort given the varied nature of the information presentation (44 tables and 51 figures) and the amount of numerical data I had to review and evaluate. I think that a part of the tables and figures have a place in the Appendix to the thesis, so the text will be easier to read.

**The conclusion** contains a synthesized presentation of the conclusions and confirmation of the hypothesis. I believe that generally formulated results of the overall research as a consequence of the completed research tasks have a place in it. Prospects for future research can also be mentioned and generally outlined here. In general, I once again confirm my high assessment of the author's scientific maturity and her ability to interpret the results of research on pedagogical phenomena and draw conclusions.

The style of writing the dissertation is scientifically sound, consistent with the modern technological vocabulary, the thought is very well logically constructed, the formulations are clear and precise. The technical layout is good.

## **8. Contributions and significance of the development for science and practice**

The dissertation is a completed theoretical-empirical study with significant practical-applied value. The research work carried out by the PhD student is labor-intensive and shows

the presence of theoretical and interdisciplinary knowledge and skills, which also determine her readiness to carry out scientific research.

The contributions presented in the dissertation correspond to the research work actually carried out and correspond to the set research objective. They are scientific and applied in nature and are essentially an innovation for modern STEM education. In my opinion, the most significant contribution of PhD student Kalina Ivanova is in the enrichment of the methodology of STEM education with the developed and practically tested methodical model for the application of STEM education, through which practical knowledge and skills for application, analysis, problem solving, critical thinking are formed and creativity.

The scientifically applied nature of the contributions is related to the developed specific scenarios of STEM lessons for the formation of practical knowledge and skills in biology and health education 7th grade and learning and innovation skills.

The developed model can also be applied to other subjects of the curriculum in Biology and Health Education, as well as be adapted for organizing and conducting STEM training in all stages of the Bulgarian secondary school.

#### **9. Evaluation of the publications on the dissertation work, the personal participation of the doctoral student**

The number and quality of publications fully correspond to the requirements of PU "Paisii Hilendarski" and its Faculty of Biology for public protection.

The PhD student presented a total of 5 (five) scientific publications on the topic of the dissertation research, which are in Bulgarian. One of the publications is independent and the others are co-authored (she is the first author), and two are in a journal that is referenced in the Web of Science. The presented publications adequately represent the individual stages of the author's work on the theoretical and empirical part of the research and can be considered as evidence of her personal participation in the dissertation research. The writing style is the same in all publications, the abstract and the dissertation.

In conclusion, I believe that the submitted documents and publications, as well as the dissertation work and the contributions presented therein, are the result of Kalina Emilova Ivanova's independent research activity.

#### **10. Abstract**

I certify that the abstract reflects in a summarized and short version all the most important parts of the dissertation work. It is presented in a volume of 31 pages and is in Bulgarian. It is well structured and technically excellent.

#### **11. Personal impressions**

I do not know the PhD student Kalina Emilova Ivanova personally.

#### **12. Critical remarks and recommendations**

I have no critical notes on my dissertation proposed for review. I recommend to standardize the spelling of the word STEM throughout the text, using Latin letters, according to the accepted national nomenclature. I think the selected 7 examples of STEM lessons, organized according to the proposed methodology, are sufficient in number, but the highlighting

of their integrative nature is not clearly done enough. In the described scenarios, it is good to allocate a place for the basic knowledge not only in biology, but also in the other subjects (mathematics, physics, etc.) that are included in the lessons. Some of them describe the importance of engineering and chemistry knowledge, but miss the opportunity to add physical knowledge (diffusion, temperature, different types of measurements, etc.), which would give them a more pronounced integrative character.

I would like to make some recommendations regarding the scientific and teaching activities of the candidate. I advise PhD candidate Kalina Ivanova to direct her future scientific research to:

- The developed model can be applied to other subjects of the biology curriculum, strengthening the integral nature of these STEM lessons.

- The more active participation of the PhD student in project activities will allow her to spread the results of the research among colleagues and enrich her professional experience with more good practices.

## CONCLUSION

The dissertation *contains scientific and applied results, which represent an original contribution to science and meet all the requirements* of the Law on the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for the Implementation of ZRASRB and the relevant Regulations of PU "Paisii Hilendarski".

The dissertation shows that the PhD student Kalina Emilova Ivanova **possesses** in-depth theoretical knowledge and professional skills in the scientific specialty "Methodology of teaching biology" by **demonstrating** qualities and skills for independent conduct of scientific research.

Due to the above, I confidently give my *positive assessment* of the conducted research, presented by the above-reviewed dissertation work, abstract, achieved results and contributions, and I *propose to the honourable scientific jury to award the educational and scientific degree "doctor"* to **Kalina Emilova Ivanova** in the field of higher education: 1. Pedagogical sciences, professional direction: 1.3. Pedagogy of teaching in ..., doctoral program: "Methodology of teaching in biology".

Plovdiv, 18.08. 2024

Reviewer: .....

(Prof. Dr. Zhelyazka Raykova)



