

REVIEW

by Assoc.Prof. Dr. Nadezhda Stefanova Raycheva, SU St. Kliment Ohridski, Faculty of
Biology, Department of Methodology of Biology Education
of a dissertation for awarding the educational and scientific degree "doctor" by: field of higher
education 1. Pedagogical sciences, Professional field 1.3. Pedagogy of education in...
Doctoral Programme Methodology of Biology Education

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 Karagyozova-Dilkova, Paisii Hilendarski
University of Plovdiv, Faculty of Biology, Department of Botany and Biological Education

1. General description of the presented materials

On the basis of the decision of the Departmental Council of the Department of Botany and Biological Education, Faculty of Biology, University of Plovdiv "Paisii Hilendarski" (Protocol №170/14.06.2024), a procedure for public defense of a dissertation on "Formation of practical knowledge and skills in students through STEM education (Biology and Health Education - 7th Grade)" was opened. The dissertation was developed by Kalina Emilova Ivanova, who in the period 01.03. 2021 - 01.03. 2024 was a full-time PhD student in the PhD program Methodology of Biology Education in the same department. By the order of the Rector of PU "Paisii Hilendarski" № RD-21-1417 of 08.07.2024 determined the composition of the evaluating jury, date, and time of public defense.

The documents submitted are under the Regulations for the Implementation of the Law on the Development of the Academic Staff in the Republic of Bulgaria and with Article 36 (1) of the Regulations on the Development of the Academic Staff of the PU.

The doctoral student has attached five publications, of which one is independent and four are co-authored. All are directly related to the dissertation research. All documents required by the procedure are available. The scientific metrics exceed the minimum requirements for obtaining the PhD according to the Appendix to Art. 1a, para. 1 of the Regulations for the Implementation of the Law on the Development of Academic Staff in the Republic of Bulgaria.

No violations of a procedural nature were found.

2. Brief biographical data for the doctoral student

The candidate, Kalina Emilova Ivanova, graduated from the Faculty of Biology and Chemistry at the Plovdiv University with the qualifications of biology teacher and chemistry teacher. Since 1998, she has been working as a teacher in various stages of secondary education. Since 2000, she has been working at "Yane Sandanski" Primary School, Plovdiv, and since 2022, she has been a deputy director of educational activities in the same school. In the period 2015-2020, she successively acquired 5, 4, and 3 Professional Qualification Degree. Mrs Ivanova completed 26 qualification courses, which are aimed at various aspects of teaching - communicative, technological, and values. She has participated in fourteen national forums, including scientific conferences and round tables. She has been active in national programs and projects of the Ministry of Education. All this speaks of initiative and developed organizational and communication skills. From the autobiographical data, it can be assumed that the PhD student is a searching personality with a motivation for self-improvement. Studying in the PhD program in Methods of Biology Education is a natural continuation of long-standing efforts for self-actualization.

3. Relevance of the subject matter and appropriateness of the set goals and objectives

Two issues for science education are at the center of the dissertation research - the formation of practical skills and the integration of content (in the particular manifestation of the idea of STEM education). Both problems are very promising for our educational system, which is still rather subject-centric, and science education is more theoretically oriented. The doctoral student argues the relevance relation of the problem to the global goals of education - certain competencies that are likely to be necessary for the successful realization and social integration of the individual in a global perspective and with relation to the organizational and managerial decisions and situations in our educational system. The research aim and objectives directly address a very current problem in science education in Bulgarian schools. The aim and objectives are correctly formulated and hierarchized. They give the impression of a well-thought-out research.

4. Knowing the problem

Kalina Ivanova demonstrated good skills in navigating the scientific literature, analyzing and structuring a theoretical study on a specific scientific problem, in this case, STEM education. The problem is discussed in terms of idea origin, nature, and application. The in-depth analysis of existing definitions and the attempt to build a working one makes a good impression. A sufficiently analytical sub-component analysis of STEM content is also made. In

the applied aspect, models and good practices for application are also sufficiently comprehensively explored and presented, and in different contexts.

Overall, not only is a good knowledge of the problem demonstrated, but the analysis itself is a kind of contribution to our educational practice and can serve as a basis for further analyses and building appropriate applied solutions.

What is missing within the analysis of the literature is a consideration of the nature of the main object of the study - practical skills with the knowledge involved.

5. Research methodology

Methodologically, at first glance, all the elements are present, but essentially some questions arise regarding:

1. The formulation of basic methodological categories:

1.1. the object is not the practical skills, which is stated in the topic and justified as the relevance of the study, but it is stated to be the whole process of learning biology and health education, grade 7, which is not justified by the actual research conducted;

1.2. practical skills are indicated as the subject of the research, and in my opinion, the methodological model, which is built and applied, enters the role of the subject.

2. The setup of the experiment:

2.1. experimenting with a control group where no work is done on the formation of the skills that are the object of the study and with an experimental group where there is a pronounced focus on the researched phenomenon. No hypothesis is needed to reach even the a priori logical conclusion that whoever is prepared will do better. The results would be more convincing if the comparison were with the same students before and after the application of the methodology.

2.2. the training time for the application of the experimental model is more than five times longer than the traditional one (4 hours vs. 22!), according to Table 8 of the thesis. Even with the considerations mentioned that some of the tasks may not be carried out in school but as home experiments or one of the topics may be applied at another time - in the last module of the curriculum, the issue of the time required remains highly debatable.

6. Characteristics and evaluation of the thesis

The dissertation consists of 166 pages of main text, references, and appendices. The main text is structured in an introduction, three chapters, and contributions. Chapter One analyses the problem of the origin, essence, and application of STEM. The exposition in this part is logical and sufficiently thorough. The specificity of the elements that enter into the

composition of the idea and their integration - science, technology, engineering, and mathematics - is analyzed. Two groups of application models are discussed - one group focuses on skills, while the others relate to the human factor - the collaboration between educators and the challenges of implementing the approach from the subjective factor perspective. An analysis is made of good practices for STEM implementation in different situational contexts - with a focus on physics, chemistry, and biology. At the end of the chapter, as a summary, the advantages and difficulties of STEM implementation as highlighted in the literature are presented. What has been presented in this chapter demonstrates the analytical-synthetic skills of the PhD student and is a good enough basis for the development of successful models for the application of STEM in real learning process conditions in our educational reality. Again, the lack of analysis dedicated to practical skills should be noted, which in my opinion has negatively affected the choice of diagnostic toolkit.

The literature consists of 33 sources in Cyrillic and 77 in Latin, with a further 6 internet document sources (5 in Cyrillic and 1 in Latin) which should be placed in notes. 24 sources are included in the Notes.

Chapter 2 is devoted to the design of the pedagogical research - the object, subject, hypothesis, aim, objectives, and research methods are formulated. Overall, the methodology appears coherent with well-defined internal links, except for notes on some elements mentioned above. This means that the PhD student can select and apply research methods following a particular experimental design. I would recommend that in future research the PhD student plan the experimental set-up more carefully to more reliably account for the influence of the factor under investigation and to analyze the object of study more thoroughly.

In this chapter, a sample design and part of the applied methodology is presented. The remaining elaborations are presented in Appendix 1. In analyzing the proposed methodological model, some problematic points have to be noted:

Apart from more time being devoted to certain topics, which is obviously at the expense of others, there is also an expansion of the content with a "reduction" of concepts and signs that are scheduled to be studied in high school - for example, the concept of ribosomes and their function, obligatory and optional structures of a prokaryotic cell, antibiosis, antibiotic resistance, probiotics, etc. The teaching of biology and health education in Grade 7 has an emphasis on taxonomy (basic taxonomic categories, grouping features, etc.), which is no longer taught in general education, and such an emphasis on one kingdom is unwarranted.

Some of the proposed tasks are debatable, for example:

Task 3 of the worksheet to the topic "Doctor, Say!", which involves analyzing doses of certain medicines - how to apply the antibiotic, how many tablets to buy..., all these considerations are made by a doctor and are not accidentally described in the prescription. I think that in this form the task may guide the practice of self-medication with antibiotics and it is good to think about it in the next application in practice;

Task 6 of the 'assessment' component on the same topic - describes a situation where a doctor makes an absurd decision, which points towards building doubts and instilling mistrust in the expertise of people who practice this profession.

Along with these remarks, several good solutions should be noted - tasks to develop divergent thinking such as the first modeling task in the topic "1,2,3 the bacteria stirred", the text and data analysis tasks in the other topics, etc.

The third chapter is devoted to analyzing the results of tests conducted before and after applying the methodology. The analysis is thorough and by the rules of testology and statistics. The doctoral student demonstrates an excellent knowledge of the norms of pedagogical diagnostics, but the question of the choice of the test as a method of diagnosis of practical knowledge and skills remains problematic. Perhaps if an analysis had been made and the nature and especially the composition of the practical skills had been clearly brought out a more reasoned choice of a method for diagnosing the object of study would have been made. The content of the tests also, even in the first instance, leads to some questions, for example: why are most tasks multiple choice and in the first levels of the taxonomy of objectives? STEM learning is mainly focused on skills that are related to analysis, evaluation, and creation, i.e., conventionally at the other end of the taxonomy. In addition to a test, the influences of the applied methodology were also investigated using a questionnaire for the individuals in the experimental group. The questionnaire is loaded with huge expectations - to diagnose motivation, attitudes, critical thinking, cooperation and communication, non-standard problem solving, etc. I think it's more a matter of surveying students' opinions about the influences they think the methodology has. At the end of the chapter, conclusions from the study are presented. Some of the conclusions are debatable and there is no direct evidence for them from this research - again, for example, "improvement in collaboration and communication" should have been accounted for by observation before and after the methodology, and such is not described in the research.

7. Contributions and relevance of the development to science and practice

As a result of the study, five contributions were made, the fifth of which refers to the presentation of the research data in the scientific literature. In general, the remaining four can

be accepted, taking into account the remarks made above in the review. I think most of the STEM learning activities developed have good ideas and can be put into practice.

8. Evaluation of publications on the dissertation work

Five publications have been submitted to this thesis, two of them in a journal that is refereed in Web of Science. One of these papers is independent and the other co-authored with the supervisor. There have been two publications in national conference proceedings, both co-authored, one with the supervisor and the other with a colleague - IT teacher. One article has been published in a national scientific and methodological journal with online access and is also co-authored with the supervisor. All articles are related to the results of the dissertation research and present it sufficiently fully in the scientific literature.

9. Personal participation of the PhD student

I have every reason to believe that doctoral student Kalina Emilova Ivanova has had a leading role in the planning, presentation, and especially in the conduct of the dissertation research. Naturally, one should not forget to acknowledge the valuable advisory role of the supervisor, Assoc. Prof. Dr. Delka Karagyzova-Dilkova.

10. Abstract

The abstract has a total length of 31 pages with the main text being 26 pages and reflects sufficiently fully and clearly the research conducted, the results obtained and the overall content presented in the thesis. A list of publications that are related to the research, as well as other publications and participations in scientific forums of the PhD student, is also given in the abstract, as required.

11. Critical comments and recommendations

The critical remarks mentioned above in the review can be summarized as follows:

- in defining the object and subject of the study and the setting of the experiment with control and experimental group;
- in the theoretical analysis - lack of analysis of the main object - practical skills as a composition;
- in the design of the methodology in terms of allocated teaching time and included teaching content;
- in the construction of the diagnostic toolkit, which is not very clearly oriented to the object of study, and the links are rather indirect.

In this regard, I have the following questions for PhD student Kalina Ivanova:

The category of time is key in determining the effectiveness of an instructional methodology, and in this regard, how would you motivate the decision to include additional

content and increase the learning time of one part of the Biology and Health Education, Grade 7 curriculum at the expense of the remaining approximately 80% of the content?

Which skills do you call practical - critical thinking, collaboration and communication, creating, applying, analyzing... or something else, and how do they relate to the diagnostic toolkit you have implemented?

12. Personal impressions

I have no direct personal impressions of the work of PhD student Kalina Emilova Ivanova. The impression of certain professional qualities of the doctoral candidate, presented above in section 2 of this review, is only based on the analysis of the autobiographical data.

13. Recommendations for future use of the dissertation contributions and results

In my opinion, the attempt to analyze the nature and application of STEM and, on this basis, to create materials that are adapted to our educational system is not only timely, but even overdue. In this regard, I appreciate the idea. The theoretical analysis dedicated to STEM is one of the contributions of PhD student Kalina Ivanova, and most of the developed practical solutions can be applied with or without modifications in different contexts, which is also a contribution of this dissertation research.

CONCLUSION

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

The dissertation work shows that the PhD student Kalina Emilova Ivanova possesses sufficient theoretical knowledge and professional skills in the scientific field of Methodology of Biology Education, demonstrating qualities for independent scientific research.

Because of the above, I confidently give my positive assessment of the research conducted, presented by the above-reviewed dissertation, abstract, achieved results and contributions, and propose to the honorable scientific jury to award the degree of Doctor of Education and Science to Kalina Emilova Ivanova in the field of higher education. Pedagogical Sciences, professional field 1.3. Pedagogy of education in... Doctoral program Methodology of Biology Education.

23.08. 2024

Reviewer:

Assoc. Prof. Dr. Nadezhda Raycheva