

REVIEW
of dissertation
for acquiring the educational and scientific degree “Doctor”
in the professional field of Pedagogy of Education in...,
procedure at the Faculty of Physics (FF)
at Sofia University “St. Kliment Ohridski” (SU)

The review was prepared by: Prof. PhD. Todorka Zhekova Stefanova from the University of Ruse, in her capacity as a member of the scientific jury according to Order No. RD38-617/20.11.2023 of the Rector of Sofia University.

Topic of the dissertation: “Comparative analysis of the educational content of “Atomic physics” in different countries”

Author of the dissertation work: Konstantin Plamenov Ilchev

I. General description of the submitted materials

1. Details of the documents submitted

The candidate Konstantin Plamenov Ilchev has presented a dissertation work and an auto-referral and a mandatory table of the Department of Physics for the degree “Doctor” according to the Rules of Procedure for acquiring scientific degrees and occupying academic positions at the Sofia University “St. Kliment Ohridski”.

An administrative package of documents related to the training procedure as a full-time doctoral student in the Academic Degree “Doctor” with the following content has been submitted in electronic form, with the following content: orders of charging and discharge with the right of defence; Certificate from the Dean of the Faculty of Physics for the 4 exams taken according to the individual plan; declaration of authorship of the dissertation work; professional CV; list of publications; author’s report on the contribution nature of the work.

The documents from the package are positioned in a request dated 4.10.2023 of the doctoral student to the head of the Department “Methodology of Training in Physics” for admission to a preliminary discussion of the dissertation work and are specifically presented on paper and in the electronic format of the package. The doctoral student has attached a document under the title “Author’s report on the contribution character of the works”, which contains a comparative table of recommended requirements of the Faculty of Physics. The comparative

table is in accordance with Appendix 1 for the additional requirements for applicants for academic degrees at the Faculty of Physics of Sofia University and although they are for the professional field 4.1. Physical sciences, it is evident that the document contains convincing authorial defence of the candidate for the scientific degree in the professional field 1.3 Pedagogy of education in

The documents submitted for the defence by the candidate comply with the requirements of the ZRASRB, PRZRASRB and the Rules on the conditions and procedure for acquiring scientific degrees and occupying academic positions at the Sofia University “St. Kliment Ohridski”. I believe that the documentation is correct and is a sure benchmark for the administrative transparency of the procedure and for objectivity in the preparation of the present review.

2. Applicant details

In a detailed autobiography in modest contours are marked several accents in the creative path of the doctoral student. Kovstanin Ilchev also acquired a Bachelor's and Master's degree in Theoretical Physics at a University in Austria from 2007 to 2012. During this period, he participated in 4 seminars. He showed very good presentation skills. In the period 2017-2019 he graduated his Masters degree from the Faculty of Physics of Sofia University in Methodology and Methods of Physics Education, with which he successfully refracted his theoretical training in physics with contemporary dimensions of didactic of physics. So was provoked his interest of a researcher in the field of methodology of physics training. In the period 2020-2023 he was a full-time doctoral student in the Ph.D. program of Faculty of Physics “Methodology of Physics Training”

The excellent knowledge of English and German, the fundamental knowledge of physics and the methods of physics training are scientifically professional and linguistic prerequisites for working in international teams and international projects. The communication of the doctoral student in these teams for the implementation of the projects was effective . These skills of the doctoral student were significantly used in the development of the dissertation work, as it made a detailed comparative analysis of curricula, programs and specific content modules in the study of atomic physics in different countries.

I appreciate that the educational status of the candidate, his international research experience, proven attitudes towards the topic of the dissertation and for its successful finalization, are sure indicators for the candidate's future academic career in the university education in Bulgaria.

3. General Characteristics of the Candidate's Scientific Achievements

3.1. Structure of the dissertation

Konstantin Ilchev's thesis paper is in a volume of 182 pages, of which 155 are the main text. The sources are quoted 120, of which 103 are in English and 17 in Bulgarian. Correctly, sources used only for figures are cited - 8. The dissertation contains 16 tables and 22 figures.

The dissertation is properly organized in the following structure – introduction, three chapters, conclusion, contributions, list of publications, literature used and one appendix. The volume in printed pages is as follows – first chapter 48 pages; chapter II -18 pages, third chapter -86 pages. The introduction is in volume of 6 pages, conclusions -3 pages. The larger volume of the third chapter is due to the described practical study in all of its stages, the conceptual design being given in the second chapter.

In the dissertation work a dissertation thesis has been proven. Except as a structure, the methodology of the study corresponds to the pedagogical dissertation as evidence of a research thesis. The design of the study is developed in two research areas, each with several research tasks, specified in research questions with implanted methods in them, so that they have been oriented in the direction of the research thesis. The first chapter is on the first research field – comparison between international and national programs and academic documentation in physics – Atomic and Nuclear Physics. The second chapter is oriented towards the other research field – a comparison of the teaching methods for studying Atomic and Nuclear Physics in Bulgaria and abroad.

The Introduction specifically and correctly inferred – purpose, tasks, object, subject, research tasks and questions. The author's approach to separating several subjects of research related to the specific task is interesting, and this is done too skillfully: compact formulation, the methods of implementation, following the procedural logic of the dissertation. At the beginning of each chapter, the relevant research questions are written in more detail and are modelling its content. This approach is useful, but it is more appropriate to combine the initial two paragraphs of the second and third chapters, i.e. the motivation is to be synchronized with the research questions of the respective chapter. This would give a more convincing direction of the content in the chapter towards the research thesis.

3.2. Contents of dissertation

Chapter 1 aims at comparative analysis between the programs in Atomic and Subatomic Physics in Bulgaria and various countries, using figures of comparative education. In the analysis of the program in Bulgaria, the doctoral student convincingly demonstrates:

- Deep and systematic knowledge in the field of Atomic and Nuclear Physics, following historical chronology, and the considerations are for even smaller systems and particles and difficulties in their mental models.
- Skills to present the programme not in a standard way, but through other descriptive approaches: definition of key meaningful indicators; and the use of good practices and observations and personal experience.
- Impressive synchronization of the scientific theses, imperceptibly and masterfully refracted in an ontodidactic context and illustrated with interesting methodical solutions /hypothetic analogy, augmented reality, physical experiment, etc. /. Some of the methodical ideas are realized in chapter 3. Thus, the Ph.D. student directs the analytical review in the first chapter to the methodology and development of the research thesis within the scope of the dissertation.
- Ability to theoretically summarise the information from the 10th grade Physics curriculum and generalise it around 19 key meaningful indicators as an approach to bench-marking with international research on the problem.

The comparative analysis of the national program with international studies is made according to a clear methodology.

The first step in the methodology are the large-scale international studies of PISA and TIMSS, which complement each other, using the results of the two studies in different age groups, different inspection ranges and measurement tools – tests, questionnaires, surveys, etc. Significant for the dissertation study is the evaluative procedure of the TIMSS Advanced, with the base scale being divided into three meaningful scales, one of which is on Atomic and Nuclear physics and three cognitive subdivisions with increasing difficulty – knowledge; application and reasoning, as well as the statistical approach to determine an available meaningful relationship. An interpretation of the presented results of the secondary analysis has been made by the PhD student, part of which can be referred to the second chapter, where the teaching methods are commented

The next logical step in the methodology is a comparison of the study programs in Atomic and Subatomic Physics at upper secondary level in different countries. Criteria for the selection of countries and provinces of countries for the bench-marking are justified so to be the national high scores in the studies of PISA, TIMSS and TIMSS Advanced /table.3, p. 45/; presentation of results, systematized by the following categories of comparison – educational structures; by a variety of curricula; by meaningful indicators, by educational

programmes. Very extensive information from the curricula in 10 countries has been studied and systematized, on the content indicators and is presented in a well-structured and color visualized table 5, adding 4 additional indicators in addition to the 19 of the Bulgarian program. /from page 55 to page 58/. After the table there is a paragraph “Conclusions”, in which the PhD student ranks the indicators according to the number of countries in which the indicator is represented. One of the paragraphs presents highlights in curricula in Slovenia, Estonia, Poland, Australia in a comparative context with the programme in Bulgaria. At the first chapter there is a conclusion, but it is not enough summarising to the chapter, and part of what is written in it can be included in the previous paragraph. The thesis in the conclusion is valuable, that the analysis carried out would be useful for making national educational decisions in all subject areas.

The second chapter is on the second research field and in the motivation to it Konstantin Ilchev refers to the teaching methods, which are commented in international studies in the first chapter. Perhaps the larger volume of the first chapter compared to the second one is due to this. I appreciate that the introduction/motivation with its good first-chapter connectivity points to the new research issues addressed in Chapter Two. The intelligent, correct and professionally engaged approach to the study of learning methods in the compared countries is impressive:

- —choice of database – Scopus, ERIC& Google Scholar/; filter articles by combining keywords with logical operators. The combination of “search string” is quoted.
- checking up-to-date reviews and excluding key terms whose review has already been published- “quantum”, or quoted by the doctoral student critical notes to articles of this review.
- Singelling out and justification of six criteria for the inclusion of articles on topics in the scope of the dissertation. After applying the first three criteria, 33 articles were filtered by Scopus and by ERIC-53 articles. After applying by the PhD student of the other three criteria-4,-ths; 5-th and 6-th and analysis of a summary or full text of the articles, they are reduced to **32**: 12 of Scopus;16 by ERIC and 4 by Google Scholar.
- Combining the ideas of Georg Geis, dated since 1984, with the results of the TIMSS Advanced 2015 and 2019 surveys, the doctoral student draws out 19 key signs of proposed activities in the methods, by systematizing them in the excellent informative design of Table 6. for the thematic areas: Atomic Physics, Nuclear Physics, Elementary Particles and a combined part.

- The interpretation of trends, categorization of the proposed activities and the methodology for quantitative measurements of the impact of the activity, the in-depth study by the doctoral student of the selected 32 articles, is correctly quoted in both the main text and the literature in the dissertation. Notice the more broken, standards-free name of paragraphs, but with rich semantic information in them – the result of the study. Some of the activities selected in Chapter Three are precisely the result of this study.

The conclusion appropriately systematises Tables 6, 7 and 8 and the decision of the researcher questions in Chapter Two. Therefore, the conclusion, as well as the introduction and rationale of the research questions to the third chapter outline a good logical connection in the second research field in the dissertation. The original idea of the author is that in addition to the description of the 7 research questions to the third chapter, it binds them and identifies them with data, analyses and conclusions in the relevant parts of the third chapter and marks them with the same identification letter.

The third chapter describes the independent study in all its stages of preparation, teaching and datasets, statistical analysis and conclusion. At the beginning of the study, the experimental group was 74, avoiding the strategy of the control group being trained in the traditional approach with the active participant – the teacher. In this way of organizing the empirical study, the results - quantitatively and qualitatively correlate to the conclusions of other large-scale international studies. These studies were appropriately selected and cited, one of which was conducted in Australia in the field of physics training and the application of a variety of interactive methods for mastering basic concepts, and this problem is within the scope of the current thesis.

The whole study is clearly described, which is in two parts, the first part is in the implementation of four lessons in four classes. For each of these lessons there are entrance/exit tests for each of the lessons to assess the effect of each of the 4 methodical units. The description of the four lessons shows the use of studied methods and techniques from the international practices and their application in these four methodical units, but in the Bulgarian school – 10.

In the topic “Photoelectric effect” are applied: Visual simulation for working in groups; Students explain to peers; Theatrical visualization of Einstein’s equation. The PhD student places personal comments on how to conduct these methods, so that Bulgarian students are as involved and stimulated as possible. At the end of the paragraph on the photoelectric effect, K. Ilchev makes a qualitative analysis of the results of the entry and exit test and links it

to research question B3 for the support of the various methods to students who have difficulty in mastering concepts from atomic physics.

Similar is the way in which the doctoral student organized and described the other topic: “Hydrogen atom. Specters.”; Referring to quoted articles in the second chapter of the dissertation, the PhD student applies the technique “Mosaic”: Working groups and expert groups, fine-tuning the set of questions to each expert group. I believe that the other reviewed articles set out in the final paragraph ‘Results’ should be in the second chapter in order to justify the empirical study, and here they should be noted in just one or two sentences in comparison with the own study. In this way, the results of the topic would be more visible and clear of detail and better structured.

On the topic “Atomic core. Radioactivity” interesting techniques are selected with correctly quoted sources: Virtual simulation/game;Scientific visualization of nuclear forces; Group Exercise/Uranus Decomposition-235/. In the results, the author notes a significant upgrade of knowledge, as a probable reason cites the more accessible concepts compared to atomic transitions.

In the topic “Nuclear Reactions and Energy” team preparation with discussion is made, in order to form the teams. A technique of group and expert work is proposed, but in this topic the emphasis is on the technique “Debates” and synchronized with another technique applied in the other lessons. K. Ilchev is able to combine international techniques and his previous lessons and realize it in this particular case.

In the last two paragraphs of the third chapter is the analysis of the data and a discussion of results in a volume of 25 pages. The “internal constancy”, data and their distribution are discussed, both from input/exit, but also from the final tests presented in the Annex to the dissertation. The data were skillfully compiled using the JASP software to obtain distributions, histograms and statistical tables in Figure 15 and Figure 16. The various methods of statistical measurements for change/in this case knowledge upgrade are described as one of the methods – the calculation of the Hake coefficient -g. is used even when discussing the results of the 4 topics quoted in the previous paragraphs. The doctoral student applied a parametric T-test to calculate the amount of the effect of knowledge upgrade through the Cohen d coefficient and found that students improve their overall score by 7.6 points as the difference/upgrade/is statistically significant. As a next step, a non-parametrical Wilcoxon test was conducted for the entire sample of 48 students for each of the individual lessons. The pearl correlation has been established – occupies a value above 0.9/major change/, the smallest effect is in the lesson on Atoms and Spectra, as confirmed by the Hake coefficient. The second part of the empirical

study, although not commented on in the main text of the dissertation, is present in the search for correlations between the total result of the output tests and the result of the final test.

The dissertation study is finalized through the discussion of the results on the research questions from B1 to B7. With regard to the research question of upgrading knowledge, it is commented that the greatest upgrade is achieved in the lesson Atomic Core/Radioactivity, for which Hake's coefficient is 0.71. The average of the coefficient for the four topics is 0.51, which is an indicator of significant improvement of knowledge. It is interesting for the doctoral student to take into account the effect "Search of the group" – the absence of 26 students – at least one absence in the 4 week period of the study. Calculates the average Hake coefficient by the individual values of the Hake coefficient for the hours the student attended, obtained a value of 0.56. The conclusion is that the exclusion of absent students from the whole sample does not lead to a significant change in the result. The large-scale international survey of Hake in 1998 on the application of interactive methods in the study of mechanics by 6542 students showed a significant upgrade – the coefficient is 0.5, which is commensurate with the coefficient from the study of K. Ilchev.

In response to research question B2, the sustainability of knowledge is commented, since the final test is held 30-40 days deferred..Figure.20 is discussed again, but in the context of the research question, as it gives two distributions of results to the same students, but at different times.The Pearson coefficient shows significant correlation, but it not only depends on the specific activities of the students according to the methods, but also other "hidden variables" related to the personality characteristics of the student.

In order to derive the difficult concepts for research question B4, the doctoral student makes a quantitative and qualitative analysis of 4 questions from the entry/exit tests, for which Hake's coefficient is less than 0.3 and their corresponding content questions from the final 6 versions tests. The main text of the thesis does not discuss the structure and function of the instrument – a final test in its 6 versions. In this paragraph, the doctoral student tries to compensate for the omission by means of a relevant and comparative analysis between an entry/exit test and a final test in the context of significant concepts: discreteness of the energy levels in the atom; quantum nature of photons; connection between energy and frequency/wave length for photons; the relationship between the energy of photons and atomic transitions. The final question of the final test examines the full understanding of the phenomena and covers all the themes of the study.The results confirm the students' ability to identify a phenomenon by picture, but again a difficulty for knowledge is confirmed – a relationship between atoms and their spectra.

The analysis of research question B6 proves that the study makes an excellent connection with Chapter Two, i.e. the key activities of the activities in individual lessons and is vividly illustrated by Table 6 of Chapter Two and Table 15 of Chapter Three.

A more synthesized and well-consuming vision of the final discussion was made in “Conclusions to the Study”, in response to a research question – B7. In the previous paragraphs of this review there is a commentary on each of the research questions, so here it is not necessary to repeat the doctoral student, as he has eruditely proved the main ones of his research.

4. Scientific publications included in the dissertation

The Ph.D. student Konstantin Ilchev has attached to his papers Authors report on the contributonal character of the works. The report contains a comparative table of the criteria of the Faculti of Physics of Sofia University for publications for the acquisition of the educational degree “Doctor” with those of the candidate. According to the criterion “A minimum of two publications, of which at least 1 is from Group I or Group II”, the doctoral student shall indicate 2 of his publications. According to the criterion “Publications with significant contributions, of which at least 1 is from Group I or Group II”, the doctoral student shall indicate 2 publications. All publications are presented by the PhD student in electronic form with the full package of the respective forum, from where the publication is.

In addition to the Author’s Report, the doctoral student mentions the 8 publications with which he participates in this procedure, marked both in the dissertation and in the authorrephere and defined by him in the following way: 4 with leading contributions and 3 with substantial contributions. He has 8 participations in conferences, 5 of which he presented in person, and in the rest he co-authored the publication, but did not attend the forum. My assessment is that the publications included in the dissertation work meet the minimum national requirements (under Art. 26(2) and (3) ZRASRB) and the additional requirements of the Sofia University “St. It’s CL. Ohridski for acquiring the educational and academic degree “Doctor” in Regional Higher Education “Pedagogical Sciences” and professional field “Pedagogy of Education in...” In this first for the candidate procedure for scientific title there are no replicating publications from those in the dissertation. There is no plagiarism proven by law in the presented dissertation work and in the autorephere.

5.. Characteristics and evaluation of teaching activity of the applicant

In the documents of the procedure there is a certificate signed by the Dean of the Faculty of Physics that the doctoral student Konstantin Ilchev has successfully passed all examinations according to the individual plan and has been tested positively during all years of

study. We accept that this document certifies that the doctoral student has completed the educational and pedagogical activity set out in the individual plan and positive attestations. There is no other information in the documents to assess the educational and pedagogical activity of the doctoral student.

6.Content analysis of the scientific and applied achievements of the candidate contained in the materials for participation in the competition

I accept the contributions that the doctoral student has made on page 155, as well as the contributions he implanted in his conclusion to the dissertation, but here I supplement them. In my analysis in the third paragraph, I pointed out some contributions, placing them there to support the achievements of the doctoral student and for the argumentation of the following summaries of me as scientific and applied contributions.

Scientific contributions:

- Developed a successful design of pedagogical dissertation on research thesis in the field of physics training: asked in the introduction research questions to each of the tasks, following the procedural logic of the dissertation. At the beginning of each chapter, research questions model its content to the dissertation thesis, and the conclusion is the answer to the same questions by confirming the internal logic of the dissertation towards the dissertation thesis.
- Introduced a non-standard approach to analysing the content and curriculum in physics for the upper secondary degree in its part Optical, Atomic and Nuclear Physics. The approach is based on ontodactic principles that the doctoral student intuitively envisioned: selection of the most significant of science, its adptation according to the age group and organisation in meaningful indicators and resources for interesting methodological solutions.
- Developed and used a clear methodology with benchmarking criteria for educational content and curricula in atomic and nuclear physics in Bulgaria and other countries around the world, applicable to other scientific fields. The analysis made by the doctoral student is an enviable awareness of information from different types of foreign language sources is useful for making national educational decisions in all subject areas.
- Developed technology for the selection of publications and their content by key features as an invariant in the range of various studied didactic innovations, and in specifics:

effective technology in a range of diverse methods of training in atomic and nuclear physics.

Scientifically Applied Contributions:

- .Didactically designed and implemented empirical research on upgrading knowledge in 4 topics in atomic and nuclear physics, using interactive methods from the studies of international good practices and proven statistical effectiveness in the conditions of the Bulgarian educational system.
- Skillful use of IDE to process primary data in tabular form and visualise them.

7. Critical comments and recommendations

In the analysis in this review, I have made specific critical notes, synthesising them here, arguing if necessary and asking questions.

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- There is lack of balance in the volume and content of Chapter /18 p. / and Chapter Three /86 p/. This would be compensated if the techniques used in Chapter Three were analysed and justified in the second chapter in conjunction with the publications from whose context they were removed. In the third chapter, only the methodology for their application in the specific lesson could remain and thus optimise its volume.
- The PhD student noted that there were two parts in the empirical study. The first part, i.e. the four lessons conducted is in detail protected in the dissertation. The second part is described, i.e. the final test. The tasks of this test themselves are given in an annex and there is no justification for the tasks in the main text. Partial analysis of the final test is present when compared with entry-exit tests in research question B.4.
- Since the third chapter examines the upgrading of knowledge about significant concepts in the subject area and about concepts that make it difficult for students, which are to be identified as problematics in the study themselves (page 150), it is appropriate to look for a link of their problem with the relevant meaningful indicators of the first chapter.
- A brighter point of view would receive the conclusion of the dissertation if it partially included leading accents from “Research Results” (B7) and thus enriched, the conclusion together with the recorded trends and recommendations would be a convincing finale for the research thesis in the dissertation.
- Technical notes: in some places, the scientific style of speech is disrupted: “the ‘drafting’ of the scores”; and in two places there are tables under No. 15.

.8. Personal impressions of the candidate

I have no personal impressions of the doctoral student Konstantin Ilchev, besides the qualities mentioned below for **the dissertation, with an overly engaged author's commentary, bearing the personal presence and feeling of the doctoral student throughout the course of his work, probably provoked in discussions with the scientific director and colleagues.** I appreciate **the desertation work** as huge and useful in scope, scientific, didactic, methodological and statistical systematised, well structured, correctly based on critically selected from an impressive number of literary sources; perfectly shaped with the resources of computer design. My recommendation is that this work should reach the Bulgarian physics teachers and scientists in the field of the methodology of Physics...

9.Conclusion After I have become acquainted with the presented **thesis paper,** Autoreferate and other materials, and on the basis of the analysis of their significance and the scientific and applied contributions contained therein, I confirm that the scientific achievements meet the requirements of ZRASRB and the Rules for its Application and the relevant Regulations of the Sofia University "St. Kliment Ohridski" for the acquisition of the educational and scientific degree "Doctor". In particular, the candidate satisfies the minimum national requirements in the professional field and no plagiarism has been established in the thesis, thesis and scientific papers presented in the competition. **I give my positive assessment of the dissertation.**

II. TOTAL CONCLUSION

Based on the above, **I recommend** the scientific jury to awarded **the educational and scientific degree "Doctor"** in the professional field..Pedagogy of... by**Konstantin Plamenov Ilchev**

01.. 2024...

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