

REVIEW

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Related to: a PhD thesis in the area of higher education 1. *Pedagogical Sciences*, professional field 1.3. *Pedagogy of Education in ...*, doctoral program *Methodology of Education in Chemistry*

Author of the dissertation: Kalin Nikolaev Chakarov

Dissertation topic: Difficult topics in the chemistry school curriculum from the perspective of students and teachers. Students' difficulties in learning organic chemistry at the basic level

Thesis supervisor: Associate Professor Alexandria Gendjova, PhD, University of Sofia St. Kliment Ohridski, Faculty of Chemistry and Pharmacy

Presentation of the procedure and general description of the submitted materials

By order No. ПД 38-87/16.02.2023 of the Rector of Kliment Ohridski University of Sofia (SU), I have been appointed as a member of the scientific jury to participate in a procedure for the defence of the PhD thesis, entitled *Difficult topics in the chemistry school curriculum from the perspective of students and teachers. Students' difficulties in learning organic chemistry at the basic level* for the award of the educational and scientific PhD degree.

The set of materials presented by Kalin Chakarov is in accordance with the Act on development of the academic staff in the Republic of Bulgaria, its Regulations and the Rules on the conditions and procedure for acquiring scientific degrees and academic positions in Sofia University St. Kliment Ohridski and includes the following documents:

- Order of the Rector for enrolment as a full-time doctoral student
- Order of the Rector for the right of PhD thesis defence
- Certificate of passing exams
- Bachelor and Master degree diplomas and annexes thereto
- Curriculum Vitae in European format
- Minutes from the department meeting related to reporting the readiness to open the procedure and preliminary discussion of the dissertation thesis
- Dissertation thesis
- Extended dissertation abstract
- Plagiarism check report
- Protocol and opinion of the supervisor on the originality of the thesis
- Declaration of originality and authenticity of the submitted documents

- Reference for fulfilment of the minimum national requirements for the educational and scientific PhD degree
- Copies of four scientific publications

The PhD student satisfies the national minimum requirements of 80 points according to the Act on Development of the Academic Staff in the Republic of Bulgaria and the Regulations for its Implementation. He has submitted a dissertation for the PhD degree award (Group of indicators A – 50 pts.), one article co-authored with his supervisor and one other co-author in a journal refereed and indexed in Web of Science (Group of indicators D (in Bulgarian Γ) – 30/3 pts. = 10 pts.), one independent article (1×10 pts. = 10 pts.) and two articles co-authored with the supervisor in a peer-reviewed journal (2×5 pts. = 10 pts.).

A brief biographical reference

Kalin Chakarov is a chemical engineer from the Chemical Engineering and Metallurgical University (CEMU) - Sofia with a Bachelor's degree in fine organic synthesis. He graduated with a grade of 5.10 and an excellent 6.00 in his thesis defence. He graduated from the Teacher of Chemistry Master's degree programme at the Faculty of Chemistry and Pharmacy of Sofia University with an overall exam score of 5.65 and an excellent 6.00 in the thesis defence. He has been a teacher for four years in several secondary schools in Sofia, and currently he is an assistant professor in the Department of General and Inorganic Chemistry of the CEMU - Sofia.

Relevance and importance of the topic

Given the global trends of declining interest of young people in studying chemistry, the topic of students' difficulties in learning chemistry at school is extremely relevant not only for Bulgaria but also on a global scale. In the introductory part, the PhD student very well motivates the choice of the topic, its relevance and importance, referring to studies of Bulgarian and foreign authors. He rightly points out that in order to improve the quality of teaching, it is important for teachers to be aware of students' learning difficulties and the reasons for them. At the same time, the doctoral candidate notes that “research related to pedagogical subject knowledge of chemistry difficulties is relatively few”. This is one of the prerequisites for the choice of topic and specific area of subject knowledge, namely organic chemistry at the general education level.

Knowledge of the problem

In the overview of the literature on the problem of difficulties in studying chemistry, a huge number of literary sources, mostly in English, but also in Bulgarian, are examined in detail and critically analyzed. Kalin Chakarov has managed to structure in an excellent way the findings from

the referenced sources, which allows him to outline the areas of most common learning difficulties, their causes and the methods for identifying them. The way the literature overview is presented in terms of structure, content, summaries and conclusions shows that the PhD student is skilled in using the scientific apparatus, gets to know the problem in depth, and this allows him to develop an adequate plan of his research.

Characteristics and evaluation of the dissertation

The dissertation contains 6 chapters, of which the first one is introductory and the last - concluding, references, 6 appendices: questionnaires for students and teachers, diagnostic test, expert evaluation card. Data are visualized in 82 tables and 15 figures and described in lists accordingly. The literature cited covers 400 sources, 16 of them in Bulgarian and 384 in English. The work is structured in a way that fully suits the research and makes it easy to read.

In the introductory part, based on the studied literature Mr. Chakarov logically justifies the choice of research issues, formulates the purpose of the study, research questions, the main methods of work, presents concisely in chronological sequence the periods of the study and its scope, describing the target groups. The working concepts and terms used in the work are briefly defined. The aim, research questions and objectives are stated clearly and convincingly.

I highly appreciate the way the outline of the work is presented in this introductory section, as the reader gets a clear idea of the nature of the work right from the start. Well-planned tasks are in line with the intended purpose and focused towards answering the research questions. The research methods chosen are appropriate to the planned activities.

The overview of the scientific literature focuses on the investigation and analysis of factors that contribute to students' difficulties in learning chemistry. The PhD student separates these factors into two groups: external and internal. The external factors stem from the peculiarities of chemistry as a science and a school subject, while the internal factors are related to the individual and are determined by the student's cognitive abilities, learning style, memorability, already formed alternative conceptions (misconceptions), attitudes, motivation, self-efficacy, etc. The external and internal factors contributing to students' difficulties, according to literature data, PhD student Chakarov has successfully summarized visually through two schemes (Fig. 2 and Fig. 3).

Based on the analysis of the literature, the doctoral student has highlighted the chemistry content areas that are most difficult for students and has identified organic chemistry as one of them. This conclusion, as well as the findings that most studies in this area refer to undergraduates and none have been found for Bulgarian students, obviously led him to investigate learning difficulties in the

field of organic chemistry. Kalin Chakarov's empirical research topics "Hydrocarbons" and "Hydrocarbon derivatives" were also not chosen at random, but were determined as a result of a detailed analysis of the 9th grade chemistry and environmental protection curriculum as well as the scientific research of authors from other countries, systematized appropriately.

In the third chapter "Methodology of the empirical research" the author presents in detail the two stages of the empirical research and the instruments used in each of them. In the introductory paragraph Mr. Chakarov illustrates the process, the samples and the methods of the research through a concise scheme (Fig. 3.2) and a table (Table 3.1), which immediately orient the reader in the implementation of the planned tasks.

For each of the two stages, the researcher has formulated a purpose and research questions, which shows that he has skilfully planned his work. The samples of students and teachers as well as the methodological toolkit, are described in detail and are adequately selected to the set objectives. The research instruments – questionnaires, interviews, diagnostic test were prepared carefully, according to the established rules. The preparation, formulation, analysis and evaluation of data shows that the doctoral student has mastered the most commonly used methods in pedagogical research.

The results of the first and second stages are presented and analysed in the fourth and fifth chapters of the dissertation, respectively. Once again, Kalin Chakarov proves that he has thought through and carefully planned the most important steps of the research: identifying students' difficulties in the learning process, searching for the causes of the difficulties and identifying strategies to overcome them.

The first stage focuses on topics from the chemistry and environmental protection curriculum for general education, perceived as difficult but as interesting, as well as the causes of students' difficulties and ways to overcome them.

Additionally, some student characteristics were studied and the perceptions of both parties in the learning process – students and teachers were compared. Ranking in tables is an appropriate way to highlight the similarities and differences in the views of teachers and their students. In search for a relationship between interest and perceived difficulty in a topic, the doctoral student found that for students there was no such relationship. The perceived most difficult field, organic chemistry, was cited by students as the most interesting, while interest in the next most difficult field, *Chemical calculations*, was low. According to teachers, the opposite is true – they believe there is a correlation between students' interest and the difficulty of the topic. Differences were also found regarding the

causes of the difficulties. For three quarters of the teachers, the factor "insufficient number of teaching hours" was decisive, while for more than three quarters of the students this was not the case.

Studies by the Organisation for Economic Cooperation and Development and its programme, known by the acronym PISA, show that the share of science classes hours in Bulgarian schools is relatively high (Bulgaria ranks 14th among 72 countries). The ratio of quantity (number of teaching hours) to quality (results) is a measure of the effectiveness of teaching. Some countries, e.g. Finland, Korea, Estonia are given as examples of high efficiency, that is high quality at the expense of quantity. In connection with the above, I would like to ask the following question to Kalin Chakarov: "What is his personal opinion on the number of statutory teaching hours in chemistry and environmental protection curriculum and what could be done in the education system to increase the effectiveness of teaching?"

The second stage focus of study is the areas of learning difficulties in organic chemistry at the basic level. The combination of several instruments: diagnostic test, questionnaires, teacher interviews allows for a multifaceted analysis of students' real and perceived difficulties, as well as their learning habits, interest in chemistry, confidence in their own abilities or so-called self-efficacy.

Based on a detailed comparative analysis of the data obtained, the author concludes that students with the least interest in the subject, the lowest level of learning habits, and low self-efficacy have the greatest difficulties in organic chemistry.

In contrast to the divergence of students' and teachers' opinions on areas of difficulty for the entire chemistry curriculum, the author finds agreement between students' and teachers' views with respect to organic chemistry. This finding is important because it could direct chemistry teachers' efforts towards appropriate approaches applied specifically to the problem areas of *Chemical Processes* and *Experiment and Investigation*. So far, the found teachers' preference for traditional methods such as lecture, explanation, etc. at the expense of context- and inquiry-based learning, historical and logical approaches, does not give grounds for optimism.

In the final, sixth chapter, the author answers the research questions, outlines the limitations of the study, articulates the contributions of the work from his own perspective, provides suggestions for applying the results, and outlines perspectives for future research. As in the previous chapters, the paragraphs and the related text are structured excellently, which testifies to the doctoral student's skills in drawing conclusions based on scientific results.

Contributions and significance of the dissertation for science and practice

The dissertation has scientific and applied features. I fully accept the self-assessment of the achievements and the way the PhD student has formulated his contributions. I confirm that the research is empirically grounded, with adequate interpretation of the data and conclusions drawn. As a result, it can contribute to the improvement of curricula and textbooks, prompt teachers to use more effective methods and strategies to overcome the difficulties identified, and be a basis and starting point for future research on students' difficulties in other areas.

Extended abstract and publications on the dissertation

Kalin Chakarov has given publicity to his dissertation research in 4 scientific articles. One of them is in *Pedagogy*, a journal that is referred, listed and abstracted in Web of Science, and the other three papers are published in *Natural Science and Advanced Technology Education*, a specialized journal listed in the National Reference List of contemporary Bulgarian scientific publications with scientific review. One of the articles in the *Natural Science and Advanced Technology Education* is an independent publication of the dissertant, and the other two are co-authored with his supervisor. The article in *Pedagogy* is co-authored with two others, one of whom is also the PhD student's supervisor. The four publications basically cover the content of the dissertation. Doctoral student Chakarov has also participated with scientific communications related to his dissertation in two scientific forums: *National Conference with International Participation "Natural Sciences 2021"* and *XIX National Conference on Chemistry for Undergraduate and Postgraduate Students*.

The extended abstract correctly reflects the structure and main results achieved in the dissertation, while meeting the requirements for this type of publication.

Personal participation of the PhD student

The achievements of full-time PhD students, in addition to being the work of the author of the dissertation, also reflect the competence and work of the supervisor. Along with the help Kalin Chakarov has received to build himself as a researcher, there is no doubt that he has also personally contributed to the dissertation research. This assessment of mine has been confirmed by the successful presentation of the work to the Department of Physical Chemistry, and the feedback from colleagues.

Personal impressions

I know Kalin Chakarov as a student in the Master's program *Chemistry Teacher*. I was a reviewer of his master's thesis, which initiated his study on the difficulties in learning chemistry. At that time, I made a recommendation to him to continue his research and develop it into a dissertation. I am delighted he has been able to do this, and I believe he did it successfully.

Critical remarks and recommendations

Unfortunately, due to the two-year period of anti-epidemic measures against Covid 19, some of the doctoral student's intentions for a more in-depth study of students' opinions remain unrealized. I'd like to recommend that Kalin Chakarov – alone or, better still, in collaboration, conduct further research in the directions, which he himself indicated in paragraph 6.5 "Prospects for future research". He could also explore the pedagogical methods that best help students overcome their difficulties.

CONCLUSION

This dissertation has addressed at the theoretical and empirical level the extremely important problem of students' difficulties in learning chemistry as a school subject. The dissertation of Kalin Chakarov is a convincing testimony that the PhD candidate possesses in-depth theoretical knowledge on the topic he has developed, as well as skills in empirical research and presentation of its results. The excellent layout in terms of structure, content and language, the outlined conclusions, the scientific theoretical and applied contributions, confirm my conviction that this is a work that bears all the hallmarks of an original authorial scientific research product and meets the requirements of the normative documents. The results of the work have been communicated to the scientific community through publications in scientific journals and presentations at scientific forums.

In view of the above, I am pleased to give a positive evaluation of the submitted dissertation and wish the dissertant to continue his professional path in the field of natural science education. I believe that the members of the honourable Scientific Jury will also have grounds for a positive evaluation and will award Kalin Nikolaev Chakurov the educational and scientific degree "Doctor" (PhD) in the area of higher education 1. *Pedagogical Sciences*, professional field 1.3. *Pedagogy of Education in ... (Methodology of Education in Chemistry)*.

20. 04. 2023

Reviewer:

(signature)

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