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The significance of chemistry curriculum for educational profiles in secondary medical vocational education

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Abstract: Investment in fundamental chemical research represents a key factor in the advancement of healthcare, which is increasingly facing the challenges of modern society. Nevertheless, the importance of chemistry in medical education is often insufficiently recognized, resulting in a weak connection between theoretical and practical aspects of instruction. Numerous studies highlight the need for a deeper integration of chemical content into vocational medical subjects. This paper analyses the attitudes of vocational subject teachers in secondary medical schools regarding the impact of chemistry curriculum reform on the quality and effectiveness of vocational instruction. The research was conducted using a descriptive method and an anonymous questionnaire on a sample of 73 teachers from medical schools across the Republic of Serbia. The findings indicate the importance of chemistry education for vocational medical training and suggest the need for improved curricular integration in secondary medical schools. These findings may serve as guidelines for the development of educational policies in the field of vocational education.

Keywords: chemical education; curriculum reform; teaching syllabus; medical profession; interdisciplinarity.

INTRODUCTION

In order for healthcare systems to adequately respond to the growing health-related challenges of modern society, continuous investment in fundamental chemical research is essential, as it represents a critical foundation for the future development of medicine.¹ Many aspects of medical practice rely on a basic conceptual understanding of chemistry, and scholars emphasize that the significance of chemical concepts in the healthcare profession is of vital importance for the advancement of society as a whole.² In secondary vocational schools with a healthcare focus, chemistry is often insufficiently integrated with vocational subjects,

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which limits students' ability to connect theoretical knowledge with professional practice. Curricula commonly treat chemistry as an isolated theoretical subject, lacking a functional connection with professional disciplines.

Students often struggle to recognize the relevance and applicability of chemical knowledge within the context of their future professional roles. The lack of interdisciplinary integration and practical application contributes to the perception of chemistry as an abstract and disconnected body of knowledge.³ As Hofstein and Mamlok-Naaman emphasize, "the effectiveness of science education is determined not only by the content delivered, but also by the extent to which students are able to connect that content with real-life and professional experiences."⁴ Contemporary didactic approaches, such as problem-based learning, contextualized instruction and laboratory work, demonstrate significant potential for increasing student motivation and fostering deeper understanding of scientific concepts.⁵ Practical applications of chemistry in healthcare contexts, including diagnostic procedures and sterilization processes, may contribute to more positive student attitudes and deeper cognitive engagement.⁶ Such teaching requires active collaboration between chemistry teachers and vocational subject teachers, clearly defined priorities and the use of methods that promote functional and interdisciplinary knowledge.⁷ As Fraser notes, teacher enthusiasm, instructional flexibility, and a supportive classroom atmosphere significantly influence students' perception of science, fostering curiosity, critical thinking and long-term motivation for learning chemistry.⁸

Curriculum reforms represent an important contextual factor influencing science teaching in vocational education. In the Republic of Serbia, the reform of secondary vocational education, introduced in 2014 through official national curriculum regulations⁹ was part of a broader educational modernization process aimed at aligning vocational education with labor market demands, improving the efficiency of schooling and optimizing the structure of subject curricula in accordance with European educational standards. The reform was implemented within the framework of national educational policy initiatives focused on increasing the relevance of vocational programs and improving student employability through curriculum rationalization. In this context, changes included a reduction in the number of chemistry teaching hours in secondary medical schools, as well as the revision and partial removal of certain chemistry contents specific to medical educational profiles. These modifications were intended to increase curricular efficiency but also raised concerns regarding the adequacy of students' chemical preparation for vocational subjects and professional practice.⁹

Although the study is grounded in the 2014 curriculum reform, available secondary sources indicate that chemistry education in secondary vocational schools in Serbia, including medical vocational programs, has not remained static in the period 2014–2025. A continuous reduction in the number of chemistry teaching

hours in secondary schools, particularly within vocational education, together with a decline in chemistry-related content and instructional emphasis, has been reported, leading to calls for increased support and greater consideration of teachers' views in the implementation of educational reforms.¹⁰ These changes are considered to have implications for students' foundational chemical knowledge and their preparedness for vocational and further academic studies.

In addition, the Institute for the Improvement of Education has published multiple amendments and updates to curricula for secondary vocational education in recent years, including programs in the field of chemistry, non-metals and graphic technologies.^{11,12} These updates indicate that curriculum development has been a continuous process rather than a single reform event.

Furthermore, this suggests that the prior chemical knowledge of students entering secondary medical schools may not be fully homogeneous across cohorts. Consequently, differences in curriculum content and teaching hours over time represent an important contextual factor that may influence teachers' perceptions of students' prior knowledge and its relevance for vocational subjects.

In secondary vocational education, chemistry represents an important foundation for understanding vocational subjects and clinical practice. However, a decline in student interest in chemistry, particularly in higher grades, has been widely observed and is often associated with insufficient connections between curriculum content and professional practice.^{4,13} Strengthening the relationship between chemistry and vocational subjects may therefore contribute to greater student motivation and improved applicability of acquired knowledge.

EXPERIMENTAL

This study investigates teachers' perceptions of chemistry education in secondary medical and social care schools, with emphasis on the integration of chemical content within vocational subjects and curriculum reform effects.

Research objectives

The research objectives include:

1. Determining the significance of students' prior chemical knowledge for vocational subject teachers in the process of vocational education.
2. Investigating the impact of reduced chemistry teaching hours on the implementation of instructional units in vocational subjects.
3. Conducting a quantitative analysis of teachers' attitudes toward the quality of vocational subject learning before and after the chemistry curriculum reform.

Research hypotheses

The following hypotheses were formulated:

1. Prior knowledge of chemistry represents an essential foundation for the successful mastery of most vocational subjects in medical schools.
2. Vocational subject teachers frequently need to explain chemical concepts, particularly within interdisciplinary teaching areas.

3. Vocational subject teachers perceive that the reduction in chemistry teaching hours negatively affects the quality of learning and understanding vocational content.

Research instrument

The study uses an anonymous electronic questionnaire applied in a cross-sectional design. The questionnaire consisted of twelve questions and was administered online using the Google Forms platform. The internal consistency (reliability) of the questionnaire was not formally tested (*e.g.*, Cronbach's alpha was not calculated), which is acknowledged as a methodological limitation due to the exploratory nature of the study and the use of a non-standardized instrument adapted for this specific research context. The data were statistically processed, and the results presented in textual, tabular, and graphical formats.

Research sample

The study was conducted on a sample of 73 vocational subject teachers from secondary medical schools in the Republic of Serbia. The research was carried out anonymously, and the questionnaire did not include any questions that would allow identification of participants (such as name, surname, or email address), while participation was voluntary. The surveyed teachers are directly involved in the vocational education process and are relevant for assessing the effects of the chemistry curriculum reform.

RESULTS AND DISCUSSION

Research results are presented using tables and a chart. The questions were grouped into three sections: Demographic Characteristics, Work Experience, and Teachers' Attitudes toward the Reform of Chemistry Education.

Demographic characteristics

The sample included 73 vocational subject teachers employed in secondary medical schools across the Republic of Serbia. Respondents provided basic demographic information (gender, age, and years of experience), which served as the basis for further analysis. A total of 81 % of respondents were female, while 19 % were male. Similar trends are reported in Horvat *et al.* (2023), where near 88 % of the 497 surveyed chemistry teachers were women, demonstrating a consistent pattern in both general and vocational science education.¹⁴ Regarding age distribution, the largest proportion of respondents belongs to the 35–45 age group (38 %), followed by 46–54 (34 %), Chart 1. This indicates that mid-career teachers represent the largest group in the sample. Comparable findings were reported previously.¹⁴

Work experience of respondents

Most respondents (39.7 %) have more than 20 years of teaching experience, while 31.5 % have between 11 and 20 years of service. Teachers with fewer than 5 years of experience constitute 15.1 %, and the smallest category includes teachers with less than one year of experience (1.4 %), Table I.

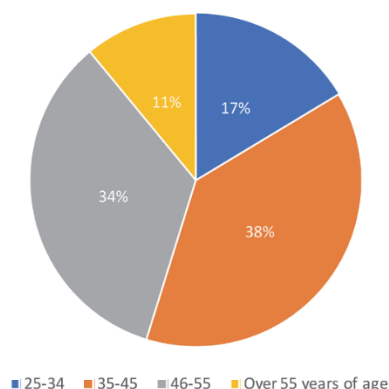


Chart 1. Age of respondents.

TABLE I. Work experience of respondents

Experience	Frequency	Percentage, %
1–5 years	11	15.1
11–20 years	23	31.5
6–10 years	9	12.3
Less than 1 year	1	1.4
More than 20 years	29	39.7
Total	73	100.0

This distribution shows a strong presence of highly experienced teachers, while younger teachers are less represented in the sample. Similar results appear in previous research.¹⁴

The fourth survey question examined the educational profiles in which teachers are engaged (Chart 2). Most participants teach in the medical nurse–technician program, which is included among the educational profiles affected by the chemistry curriculum reform.

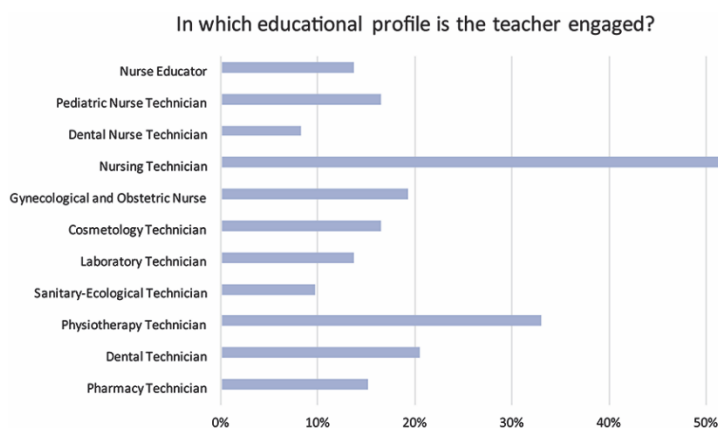


Chart 2. Educational profiles in which teachers are engaged.

Teachers' attitudes towards the reform of chemistry education

Within the framework of statistical data analysis, particular emphasis was placed on examining teachers' attitudes regarding the impact of the reform on the functional acquisition of content in vocational subjects within the fields of health and social care. The fifth question examined how frequently chemistry content is integrated into vocational subject. Respondents were offered the following options to choose from: very often, often, occasionally, rarely, never.

The results obtained from this question are presented in Table II.

TABLE II. Teachers' attitudes towards the importance of chemistry in vocational subjects

To what extent is chemistry content integrated into the vocational subjects in which the teacher is engaged?		
Extent	Percentage, %	Frequency
Very often	22	30.1
Often	30	41.1
Occasionally	19	26.1
Rarely	2	2.7
Never	0	0
Total	73	100.0

According to the results presented in Table II, the majority of teachers (41.1 %) report that chemical content is often integrated within the framework of professional subjects. An additional 30.1 % of teachers consider this integration to be very frequent. Thus, more than 71 % of teachers acknowledge frequent interdisciplinary integration. Comparable results are found at the University of San Francisco, where chemistry was identified as a foundational discipline for understanding core health science competencies.¹⁵

Teachers were also asked to evaluate the role of chemical literacy in vocational subjects (Table III).

TABLE III. Teachers' attitudes regarding the importance of chemical literacy for studying professional subjects

To what extent do you consider chemical literacy important for the effective study of professional subjects in the fields of healthcare and social care?		
Importance	Percentage, %	Frequency
Very important	36	49.3
Important	29	39.7
Moderately important	8	11.0
Slightly important	0	0
Not important	0	0
Total	73	100.0

The results indicate a high level of agreement among teachers regarding the functional role of chemistry in vocational learning. This finding is consistent with contemporary literature on critical chemical literacy, which views chemistry as a multidimensional tool for professional and societal engagement.¹⁶ In addition, the findings parallel the perspective that socio-scientific issues help students integrate conceptual knowledge with real-world contexts, thereby strengthening motivation and applicability.¹⁷

In the subsequent phase of the study, participants were presented with statements related to the reform of chemistry education, aimed at examining their attitudes toward its impact. Teachers expressed their level of agreement using a Likert scale from 1 to 5, where 5 indicated “strongly agree” and 1 “strongly disagree.” For analytical purposes, the values were interpreted within three categories: negative attitude (1–2), neutral attitude (3) and positive attitude (4–5), in accordance with the validation conducted by Xu and Lewis.¹⁸ The results are presented in Table IV.

TABLE IV. Assessment of teachers' attitudes as descriptive statistics; $N = 73$

Question	Minimum	Maximum	Mean value	Standard deviation
Has the reduction in the number of chemistry lessons affected the quality of learning in professional subjects?	2	5	4.36	0.788
Do students experience difficulties in studying instructional units that involve integrated chemical content?	2	5	4.18	0.839
Does the reduction in the number of chemistry lessons necessitate additional instructional time in professional subjects that require a solid foundation in chemistry?	1	5	4.05	1.039

Teachers strongly agree that reducing chemistry teaching hours negatively affects the quality of learning in vocational subjects. They also report that students struggle with content requiring chemical understanding. Opinions on whether additional chemistry lessons should be introduced within vocational subjects are somewhat more varied ($M = 4.05$), indicating differences in the perceived feasibility of such measures.

The following question addressed the importance of prior knowledge in chemistry for teaching vocational instructional units, offering a binary choice of answers (“yes” or “no”). The results indicate a high level of agreement among teachers regarding the importance of prior knowledge in chemistry for the successful mas-

tery of vocational instructional units, with 91.8 % of respondents stating that chemical literacy is essential for this process. Only 8.2 % of teachers expressed an opposing view. These findings are consistent with existing literature emphasizing the role of chemistry in healthcare education.¹⁹

In the next question, the study examined teachers' perceptions regarding the impact of the reduced number of chemistry lessons in upper secondary grades on the need for additional explanations during vocational instruction. The question posed was: "Do you believe that the absence of chemistry as a subject in the upper grades requires vocational subject teachers to explain related chemical concepts?" A large majority (89 %) believe that eliminating chemistry from upper secondary grades requires vocational teachers to explain chemical concepts themselves. These findings correspond with Pienta's perspective on the importance of chemistry in professional formation.²

The next question focused on assessing the teachers' self-evaluation of their competence in explaining chemical concepts. It was phrased as follows: „Do you consider yourself, as a vocational subject teacher, sufficiently competent to explain to students the chemical concepts included in the teaching units? Only 37 % of vocational subject teachers consider themselves sufficiently competent to explain chemical concepts, whereas 63 % do not. In the following question, teachers were presented with various options as potential solutions to this issue. The research results indicate that a significant proportion of the surveyed teachers (78.1 %) support increasing chemistry hours and initiating a new curriculum reform. Furthermore, 15 % of teachers emphasize aligning chemistry and vocational curricula. On the other hand, a relatively small percentage of teachers (5.5 %) support the need for additional professional development in chemistry. The remaining 1.4 % of respondents selected other responses not specified within the predefined categories.

Regarding the impact of the reform on the quality of students' knowledge, three options were examined: positive impact, negative impact, and inability to assess, with the aim of obtaining a comprehensive picture of teachers' perceptions concerning the effects of the reform. The results indicate that 46.6 % of teachers believe that the reduction in the number of chemistry classes has negatively affected the quality of learning in vocational subjects, while 30.1 % did not recognize a significant impact. The remaining 23.3 % of respondents were either uncertain or lacked sufficient data to form a clear opinion. In the subsequent analysis, a possible correlation was examined between the teaching experience of respondents and their views on the impact of the chemistry curriculum reform. The aim was to determine whether teachers with more extensive professional experience exhibit a more critical stance toward the reform changes, or whether the opinions are evenly distributed regardless of years of service. The results presented in Table V.

Although negative perceptions of the reform were predominant at the overall sample level, the distribution of responses within individual experience groups

revealed a more differentiated pattern of attitudes. Positive assessments were more frequent in several categories of teaching experience, whereas more critical views were observed among some groups of more experienced teachers. However, statistical analysis showed no significant relationship between years of teaching experience and perceptions of the reform's impact ($r = 0.153$, $p = 0.197$). These findings suggest that teachers' attitudes toward the reform cannot be explained by differences in professional experience alone.

TABLE V. Correlation between teachers' years of service and their attitudes (in %) toward the impact of the curriculum reform

Attitude	Years of service				
	<1	1–5	6–10	11–20	20+
Positive	100	54.55	66.67	30.43	51.72
Unable to assess	0	18.18	22.22	30.43	20.69
Negative	0	27.27	11.11	39.13	27.59

CONCLUSION

The results of this study indicate that the majority of vocational subjects' teachers recognize the importance of prior chemistry knowledge for the successful mastery of those subjects. In the context of the reduced presence of chemistry in the curriculum, vocational subject teachers increasingly assume the role of explaining fundamental chemical concepts, thereby revealing perceived challenges associated with the educational reform.

A considerable proportion of teachers reported that the reduction in the number of chemistry hours has negatively affected the quality of vocational education. Although some respondents consider themselves capable of compensating for these deficiencies, the findings point to the need for improved curricular coherence and stronger integration between chemistry and vocational subjects in secondary medical education. However, the findings also suggest that teachers' perceptions are not entirely uniform and should not be interpreted as strictly predominantly negative. Instead, the results indicate a more nuanced and differentiated pattern of responses across the sample.

The results of this study largely support the proposed research hypotheses. The first hypothesis was confirmed, indicating that prior chemistry knowledge represents an important foundation for the successful learning of vocational subjects in medical secondary schools. The second hypothesis was also confirmed, as vocational subject teachers reported a frequent need to explain chemical concepts, particularly within interdisciplinary teaching contexts. The third hypothesis was only partially supported, suggesting that although many teachers perceive reduced chemistry teaching hours as having a negative impact on learning vocational content, this perception was not equally strong across all respondents. Overall, the

findings emphasize the close relationship between chemistry and vocational subjects in medical education. They further highlight the importance of maintaining adequate chemistry instruction and strengthening the integration of chemical concepts within vocational curricula. Such efforts may contribute to improving students' understanding of professional content and the development of relevant competencies.

The findings provide partial support for the initial research assumptions regarding the importance of chemistry knowledge and the perceived impact of curriculum reform on vocational education. Although differences were observed among teachers with varying levels of professional experience, the correlation between years of service and attitudes toward the importance of prior chemistry knowledge was not statistically significant ($r = 0.153$, $p = 0.197$).

Overall, the findings highlight the importance of aligning curriculum reforms with the educational and professional needs of vocational education, particularly through stronger interdisciplinary integration and the functional application of chemistry knowledge in professional practice. Rather than indicating a uniform negative evaluation of the reform, the results point to a complex set of perceptions that reflect both perceived challenges and adaptive responses among teachers.

The findings of this study should be interpreted in light of several limitations. First, the research was conducted on a small sample of vocational subject teachers, which may limit the generalizability of the results. Second, the study was based only on teachers' perceptions, students' opinion was not included. Finally, the questionnaire was developed specifically for this study and did not undergo formal psychometric validation, which should be taken into consideration when interpreting the findings. Future research will include larger samples, validated instruments and student opinions in order to provide a more comprehensive evaluation of the impact of chemistry curriculum reforms.

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ИЗВОД

ЗНАЧАЈ НАСТАВНОГ ПЛАНА И ПРОГРАМА ХЕМИЈЕ ЗА ОБРАЗОВНЕ ПРОФИЛЕ У СРЕДЊЕМ МЕДИЦИНСКОМ СТРУЧНОМ ОБРАЗОВАЊУ

ДАНИЦА РАШИЋ, САША А. ХОРВАТ, ДУШИЦА Д. РОДИЋ И ТАМАРА Н. РОНЧЕВИЋ

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Улагање у фундаментална хемијска истраживања представља кључни фактор у напретку здравствене заштите, која се све више суочава са изазовима савременог друштва. Ипак, значај хемије у медицинском образовању често није довољно препознат, што доводи до слабе повезаности теоријских и практичних аспеката наставе. Бројне

студије указују на потребу за дубљом интеграцијом хемијских садржаја у медицинске стручне предмете. Овај рад анализира ставове наставника стручних предмета у средњим медицинским школама о утицају реформе наставног плана и програма хемије на квалитет и ефикасност стручне наставе. Истраживање је спроведено дескриптивном методом и анонимним упитником, на узорку од 73 наставника из медицинских школа широм Републике Србије. Резултати делимично потврђују полазне хипотезе и указују на потребу за систематским унапређивањем наставе хемије у медицинским школама. Ови налази могу послужити као смернице за развој образовних политика у области стручног образовања.

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