Journal of the Serbian Chemical Society
JSCS-info@shd.org.rs • www.shd.org.rs/JSCS

J. Serb. Chem. Soc. 80 (3) 435–452 (2015)
JSCS–4727

UDC 371.124:54+011.892+373.5
Original scientific paper

Chemistry curricular knowledge of secondary school teachers

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(Received 2 October, revised 7 December 2014, accepted 8 December 2014)

Abstract: In the course of this research, the extent of chemistry teachers' professional knowledge related to the structure, contents and application of chemistry curricula and their components was investigated. The research comprised 119 teachers from 69 secondary schools (25 grammar schools and 44 vocational secondary schools). The questions in the questionnaire referred to general curriculum knowledge, knowledge of chemistry curriculum and the views/assessments of the teachers concerning the necessary changes in the curricula currently in effect. The teachers' answers showed that the most important components of the curriculum for their work are the goals and operative tasks/outcomes. The results indicated that information in the curriculum components exits that remains unused although it is relevant for a certain level of planning. Among the teachers in the sample, higher percentages of those with an appropriate teachers' training programme applied information from the curriculum within the teaching process through demonstration methods and problem solving. The research that was conducted provides a basis for defining the indicators for monitoring the level of teachers' capability to apply curricular knowledge in their practice. Such indicators are important for creating teaching situations and teachers' activities within the framework of initial education and continuing professional development of teachers.

Keywords: curricular knowledge; curricular components; annual work plan; monthly work plan; lesson plan; chemistry teaching.

INTRODUCTION

The needs of contemporary society require a constant redefining of the education of the young. In keeping with this, what also undergoes changes are requirements concerning teachers' competences (knowledge and understanding, skills, dispositions), which would enable an efficient realisation of the expected outcomes of the education of the young.[1] The said competences should be formed through initial teacher education (ITE) and further developed through

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doi: 10.2298/JSC1401002121T

continuing professional development (CPD). They represent a complex combination of knowledge, skills and value judgements.[2] Competences comprise teachers' knowledge about learning, the goals of education, outcomes, resources and the broader social context of teaching and education.[1,3]

Pedagogical knowledge of chemistry is part of chemistry teachers' competences that could be defined as a combination of pedagogy and the content of chemistry.[4–6] Today, the professional development of teachers also requires a technological content to pedagogical knowledge, which is necessary for the application of contemporary technologies in the teaching process.[7,8] Knowledge of science curricula, together with knowledge of students' understanding of science, knowledge of assessment of scientific literacy, knowledge of instructional strategies, shapes a teacher's orientation to science teaching.[9] This encompasses knowledge of two categories: the mandated objectives and tasks, and specific curriculum-related programmes and materials. The first category encompasses knowledge of the objectives and tasks that pupils are to accomplish within the framework of a subject, as well as knowledge of the manner of accomplishing them within the framework of the given topics during the course of the school year. This knowledge also includes a teacher's knowledge about vertical curricula (the curricula of the previous and the following school year). Awareness of horizontal connections among different subjects is also required, as is knowledge of the curricula and attendant materials of specific additional programmes in special areas and scientific topics relevant to teaching. This expresses the need for teachers to continually become informed about development projects, the results of which would improve the teaching practice, and about reforms that are periodically enacted. The extent to which teachers will successfully and appropriately introduce the most important results into their teaching practice depends on this.

Knowledge of the curricula and being trained to interpret them are considered to be important components of a teacher's knowledge. There are different models of the structure of a teacher's knowledge and they all emphasise the necessity of educating teachers in the sphere of the curriculum.[10–13]

In their model, Barnett and Hodson[14] included the following components of the knowledge of science teachers: academic and research knowledge, pedagogical content knowledge, professional knowledge and classroom knowledge. Knowledge of curricular documents and curriculum planning were viewed as components of professional knowledge. Professional knowledge comprises knowledge of curriculum documents, the duties of teachers, union matters, information about school administration and procedures for communicating with parents.

The curricular knowledge refers to the obligation of a teacher to be acquainted with the existence and functions of this document. Curricular knowledge serves to organise, present and adjust the contents of the curriculum, teaching topics, problems and issues related to the varying interests and abilities of the pupils. Curricula are continually being changed, and a teacher cannot get all the necessary instructions for his/her future work through education. Teachers' education does not represent the acquisition of a certain number of ready-made solutions, but constitutes the development of a complex body of knowledge that is to be applied in resolving specific practical problems in accordance with the curricula currently in effect.[15] Researchers agree that subject matter plays the key role in a meaningful linking of the components of a teacher's knowledge.[16,17]

The results of research of the formation of curricular knowledge in pre-service and in-service teachers do not shed light on the ability of teachers to translate specific curricular material into practice. Research for the most part encompasses the most frequent teaching topics in the curricula and the necessary corpus of knowledge, explaining the most frequently encountered teachers' and students' fallacies (misconceptions) that make certain contents difficult to understand and clarify. Still, each teacher who possesses a more or less formed knowledge of the curriculum teaches according to the curriculum which he/she should adjust, transform and realise in the classroom in accordance with a great number of contextual factors. The forming of curricular knowledge may depend on a great number of factors, the initial education of teachers, the type of school where they work and the length of their professional experience.[18]

A survey that should show how teachers use the chemistry curricula for the planning and realisation of their teaching practice was conducted. Components of the Carlsen model of teacher knowledge, general curriculum knowledge and knowledge of chemistry curriculum (specific knowledge of science curriculum) were monitored.[13] General curriculum knowledge presupposed knowledge of the role of certain components and the curriculum as a whole. Knowledge of the chemistry curriculum presupposed monitoring how teachers translate the chemistry curriculum into classroom activities.

General curricular knowledge[4] and the knowledge of chemistry curricula[9] presuppose a teacher's knowledge of the objectives and tasks that students are supposed to accomplish within the framework of a subject. Using the curriculum, a teacher should know and interpret this document, both from the viewpoint of general pedagogical knowledge and from the viewpoint of knowledge of chemistry contents.

The purpose of the conducted survey was to investigate the curricular knowledge of chemistry teachers in grammar schools and secondary vocational schools. Monitored were indicators referring to:

1. general curriculum knowledge (knowledge of the purpose of the curriculum),

2. knowledge of chemistry curriculum (knowledge and application of information from the chemistry curriculum) and

3. views about the necessary changes in the current curricula.

The analysis of the data obtained from the questionnaire was supposed to establish:

– how teachers asses the usefulness of the curriculum and some of its components for various phases of planning (Q6, Q7, Q8, Q9),

–- how they assess the usefulness of the curriculum for the realisation of the most important and most frequent teaching situations, and which components of the curriculum they single out as the most important ones (Q10, Q11, Q12) and

– which curriculum components, as they see it, require changes (Q13).

Moreover, whether their replies were influenced by their initial education of teachers, the type of school where they work and the length of their professional experience influence were investigated.

DATA COLLECTION

The research sample

The questionnaire constructed for the purpose of this survey was completed by 119 teachers working in grammar schools and secondary vocational schools. The survey was conducted in 2013. Of the participating teachers, 41 work in grammar schools, while 78 work in secondary vocational schools. These schools were located in 41 cities and towns in Serbia. Since no reliable data concerning the total number of chemistry teachers in Serbia could be obtained, the response rate was calculated based on the number of schools in the sample.[19] According to official data,[20] there are 494 secondary schools in Serbia. The teachers in the sample came from 25 grammar schools and 44 secondary vocational schools (14.0 % of the total number of secondary schools in Serbia).

The instrument and the procedures

The questionnaire, given in the Supplementary material to this paper, completed by the teachers consisted of 13 questions (quoted along with the survey results). The first five questions referred to personal information about the respondents.

The questionnaire comprised closed-type questions and one open-type question. The closed-type questions were of the two-option response variety, multiple-choice questions and those with a Likert scale. Three closed-type questions were to be answered by ticking a box in the table.

The questions were formulated based on an analysis conducted beforehand concerning the structural components contained in the current curricula. The questionnaire required the teachers' assessment concerning the applicability of the current curricula, the importance and usefulness of the information mediated by the curricula in their entirety, and also through their individual components. Researched were the way teachers translate information from the curriculum into corresponding classroom activities and how they select the appropriate contents and methods.

The first version of the questionnaire was given to four expert chemistry teachers. Based on their comments and suggestions, a new version was prepared. This questionnaire was presented in a seminar in which twenty chemistry teachers participated. Based on their responses, the clarity of the formulations of the items was improved, as well as the order of the items in the questionnaire. Subsequently, the final version of the present questionnaire was constructed.

Data analysis

The response frequency, arithmetical mean and standard deviation were determined. The statistical significance of the differences between the answers given by the teachers from different schools, with different initial education and working experience, were determined by means of the χ^2-test of independence as a measure. When dealing with two variable categories (*e.g.*, grammar schools and vocational schools), the value of the Yates Correction for Continuity was monitored. In the cases where more than 20 % of the frequencies were lower than 5, the values were determined through the Exact Statistics and Monte Carlo methods. For the interpretation of the χ^2-test results, the 95 % confidence level was selected. We used IBM SPSS Statistics (Version 20.0) was used for the for the χ^2-tests. When no statistically significant differences between the answers given by teachers from various categories were established, the results in this study were presented for the entire sample.

RESULTS AND DISCUSSION

Respondents

The structure of the sample of the teachers surveyed is presented in Table I. Of the overall number of the teachers surveyed, 41 (34.5 %) work in grammar schools (GS), while 78 (65.5 %) work in secondary vocational schools (SVS). The majority of the teachers (42.9 %) had between 10 and 20 years of working experience. Only 9.2 % of the teachers were prepared for working in a school through initial education, whereas the others completed one of the non-teaching courses of studies at the Faculty of Chemistry or some related faculty, *e.g.*, the Faculty of Technology and Metallurgy. Nine of the teachers (7.6 %) had obtained some form of post-graduate education (specialisation, Master's Degree). The sample comprised 84.0 % of women. A little less than half of the teachers included in the sample belonged to the age group between 40 and 50 (44.5 %). The second largest group in the sample were teachers between 50 and 60 years of age (27.7 %).

TABLE I. General characteristics of the respondents (N = 119)

Type of school	*N* (%)	Years of work as teachers	*N* (%)	Initial education	*N* (%)
Grammar School (GS)	41 (34.5)	Less than 5	11 (9.3)	Faculty of Chemistry, Teacher-training programme (FC-TTP)	11 (9.2)
Secondary Vocational School (SVS)	78 (65.5)	5–10	13 (10.9)	Faculty of Chemistry, Non-teacher-training programme (FC-NTTP)	84 (70.6)
		10–20	51 (42.9)	Other non-teacher-training faculties (ONTTP)	24 (20.2)
		20–30	28 (23.5)		
		More than 30	16 (13.4)		

General curriculum knowledge and knowledge of the chemistry curriculum

Curricular knowledge presupposes knowledge of the purpose and the manner of implementing this document as a basis for the overall planning and realisation of teaching.[9] When asked for what level of planning they use the curricula, the majority of the teachers replied that they use them for annual planning (65.5 %), and for monthly planning (43.5 %). Viewing the sample as a whole, only a few teachers use the curricula when planning individual lessons. However, a statistically significant difference was established when the answers of teachers with different initial education were compared ($\chi^2(2.119) = 15.84$, $p = 0.00$). Only 18.2 % of the teachers who were prepared for teaching through their initial education (FC-TTP) actually use the curriculum for preparing a lesson plan. A greater percentage (34.2 %) of the teachers who completed non-teaching courses of studies at the Faculty of Chemistry (FC-NTTP) use the curriculum for preparing individual lessons. Of the teachers who completed non-teaching courses of studies at other faculties (ONTTP), 77.3 % use the curricula for preparing individual lessons.

The teachers who attended the teaching and non-teaching programmes of studies at the Faculty of Chemistry mostly work in grammar school (87.2 %). There were no statistically significant differences concerning their answers to questions about their use of the curricula for various levels of planning. As regards the answers of the teachers working in SVS, depending on their initial education (teaching and non-teaching programmes), there were statistically significant differences in their use of the curricula for preparing annual plans ($\chi^2(2.73) = 6.64$, $p = 0.04$) and planning individual lessons ($\chi^2(2.73) = 0.45$, $p = 0.00$). When making annual plans, the curricula are mostly used by those teachers who were trained for teaching (100 %), followed by those who attended a non-teaching course of studies at the Faculty of Chemistry (68.9 %) and the other teachers (50 %). As regards the planning of individual lessons, the curriculum is used the least by those teachers who attended a teacher training programme at the Faculty of Chemistry (12.5 %), followed by those who completed a non-teaching course of study at the same faculty (35.6 %), and 80.0 % of the teachers who graduated from other faculties.

The results obtained indicate that the curriculum, as a document prescribing the obligatory contents (teaching topics) and the number of lessons for their realisation, is used the most for macro planning.

When asked which components, *i.e.*, which data are useful to teachers in their work, more than half singled out the operative tasks/outcomes (Fig. 1). This was followed, in terms of the frequency of the answers, by the goals and tasks of chemistry (46.2 %). One-third of the teachers encompassed by the sample found the contents of topics a useful component of the curriculum. The curriculum component designated as instructions for the realisation of a topic was singled out as informative by a small number of the teachers, who found the component the manner of realising the curriculum more useful. The low frequency of selecting these two components was probably connected with the fact that, within the current curricula, neither of them provides specific but generalised instructions. The fewest teachers (6.7 %) singled out the curriculum component pertaining to additional work with students as useful. In other words, apart from the obligatory segments of teaching, teachers find very little information in the curricula of use for additional work with those students who, in keeping with their interests and knowledge, should be offered additional contents.

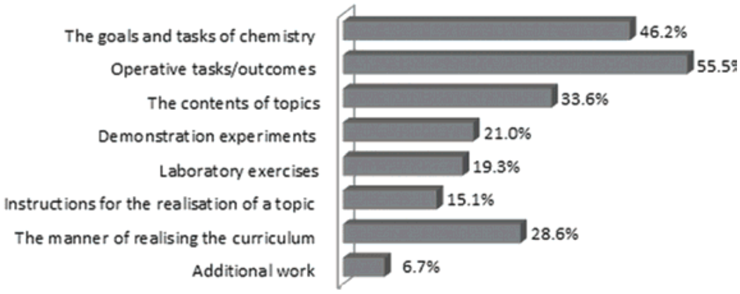

Fig. 1. The importance of information mediated through curriculum components (*N* = 119).

Most of the teachers surveyed (58.0 %) have used the curriculum in an equal measure during the course of their teaching career even though it remains unchanged. Compared to the initial years of their work, 11.8 % of the teachers feel a greater need to use the curriculum, whereas 26.1 % of the teachers tend to use it increasingly less over time. This also refers to the curricula that have remained unchanged for years.

The ninth question in the curriculum linked the levels of planning (annual, monthly, individual lessons) and curriculum components. Among the curriculum components used by the teachers for particular levels of planning, most of them (64.7 %) singled out the goals and tasks of chemistry for annual planning, whereas 58.8 % of them singled out the component designated as operative tasks/ /outcomes for the monthly planning of teaching and for planning individual lessons (Fig. 2). The component instructions for the realisation of a topic is used by the least for annual planning, and is useful to a greater number of the teachers (46.2 %) for planning a lesson. Similarly, the component list of demonstration experiments is of greater importance to a larger number of the teachers for planning a lesson than for monthly and annual planning. In addition, the component the manner of realising the curriculum, according to the answers supplied by the teachers, is the more useful for planning a lesson (38.7 %) and for monthly planning (35.3 %) than for yearly planning (25.2 %). The reason why these components are not used by the majority of the teachers has more to do with the fact that the currently available information is not relevant for the monthly level of planning, and less with the functional applicability of the teachers' general curriculum knowledge.

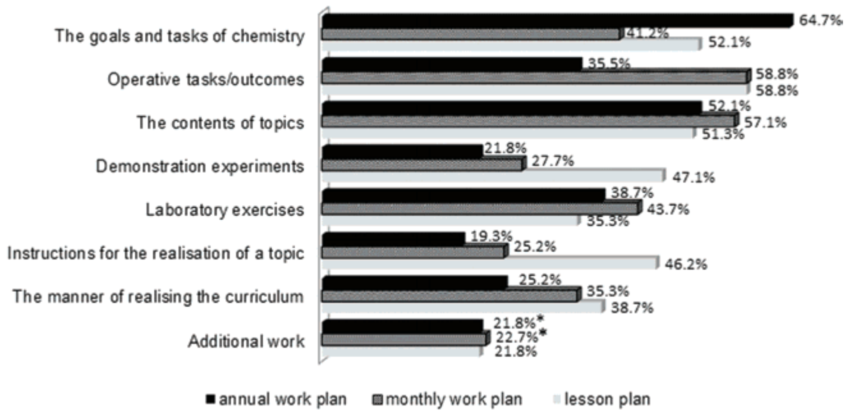

Fig. 2. The applicability of curriculum components for planning teaching.

The teachers' answers indicate that their curriculum knowledge does not enable them to recognise which components from the curriculum may be of importance for annual planning, especially when it comes to planning the overall funds required for the realisation of chemistry teaching in the course of a school year. Thus, for example, more than 60 % of the teachers do not use the information about demonstration experiments and laboratory exercises from the curriculum in their annual planning in order to assess the overall needs for laboratory equipment and substances required for the realisation of the experimental part of chemistry teaching during the course of the school year. In this respect, there was no statistically significant difference between the answers of those teachers who were initially educated for teaching and those who were not.

The current curricula neither develop some teaching units in detail, nor do they do so when it comes to the manner of work to be applied in some lessons. Lesson planning encompasses devising students' activities and planning the means that enable the outcomes envisaged by the curriculum for each segment of a lesson to be achieved. No statistically significant differences in connection with the use of the curriculum for the purpose of planning a lesson were found among the teachers with different initial education working in grammar schools. However, there is a statistically significant difference between the answers of the teachers with different initial education working in secondary vocational schools concerning the use of the curriculum for annual planning and lesson planning. Actually, all the teachers who were initially educated for working in a school use the curriculum for annual planning, and in this respect they differ from the other teachers in a statistically significant manner. As opposed to this, the least number of them use the curriculum for lesson planning. The greater degree of confidence of these teachers and their greater autonomy when it comes to deciding what a lesson should be like are probably partly a result of their initial education and the previously reviewed approaches to the realisation of curricular contents. On the other hand, the teachers who did not have that form of initial education, when faced with new curricula (and the greatest changes over the past 15 years have occurred in the domain of vocational school curricula) and new requirements, feel a greater need for guidance provided by the curriculum. Apart from the curriculum, the teachers who were not prepared for teaching through initial education rely on the textbook when preparing a lesson and the textbook is often considered to constitute additional material.[21,22]

As already indicated, in their annual planning, the teachers do not use the components demonstration experiments and laboratory exercises for planning the overall equipment required for the realisation of chemistry teaching during a school year, whereas a number of them use the component laboratory exercises in their monthly planning, when they establish how much time is required for realising the laboratory exercises. The component demonstration experiments become important for a large number of teachers at the level of lesson planning.

The curriculum component that pertains to additional work with students is used in different ways by the teachers working in GS and SVS at the level of preparing the annual work plan ($\chi^2(1.119) = 9.33$, $p = 0.00$) and the monthly work plan ($\chi^2(1,119) = 8.15$, $p = 0.00$). In grammar schools, this component is used by 39.0 % of the teachers for preparing their plans at both levels of planning. In secondary vocational schools, this component is of importance for preparing the annual work plan for 12.8 % of the teachers and 14.1 % find it important for preparing the monthly work plan. There is a significant difference between the number of the teachers working in grammar schools and secondary vocational schools who use this component in their annual and monthly planning. The instructions for additional work are more important to the teachers working in grammar schools, which is explained by the fact that there are a greater number of students there who are high achievers, interested in further education in the domain of natural sciences and in various kinds of additional activities (competitions, projects, *etc*.). On the other hand, the programme does not provide any recommendations for additional support for such students who are faced with a lack of success in their learning.

Curricular knowledge, generally speaking, and knowledge of the chemistry curriculum are contained within the competence of chemistry teachers required to transform the curricula specific to chemistry into real teaching situations in the classroom. The aim of Q10 was to investigate which information from the curriculum guides this process. When answering this question, the teachers assessed the usefulness of information from the curriculum in terms of selecting the teaching/learning method, devising activities and teaching situations. The teachers assessed the degree of usefulness on a scale of 1 to 5 (1 – not at all, 2 – negligibly small, 3 – small, 4 – mostly and 5 – completely). The calculated mean values and standard deviations are given in Table II. The teaching situations in Table II are classified based on the decreasing mean values pertaining to Q10. The calculated mean values ranged from 4.08 to 2.88. The results show that the teachers are best guided by the curriculum in the case of activities aimed at explaining and defining new concepts, whereas it provides the least support in organising the preparation of projects.

Answering Q11, the teachers specified for every activity which components from the curriculum they use for planning and realising the given activity. The percentages relating to the answers to this question are presented in Table II.

The answers given by teachers with different initial education differed statistically to a significant degree with regards to the translation of certain information from the curriculum into some of the classroom activities under consideration (the values for the Cramer V indicated that the initial teacher education had some influence, Table III). The information offered in the curriculum pertaining to these activities is mostly used by the teachers who were educated at the Faculty of Chemistry to be chemistry teachers. It can be seen from the results that the teachers who attended a teacher training programme translate information from the curriculum into teaching situations aimed at systematising the curriculum contents, acquisition of curriculum contents through problem solving, demonstration of experiments and other teaching aids to a greater degree than those who did not.

When it comes to demonstrating experiments and organising laboratory work, most of the teachers use the curriculum components that explicitly refer to these activities. Among the teachers in the sample, higher percentages of those who had partaken in an appropriate teachers training programme applied information from the curriculum within the teaching process through the demonstration method and problem solving. This is indicated by the answers of the teachers with different initial education concerning translation of curriculum information into these classroom activities (Table III). A necessary segment of chemistry teachers' pedagogical chemical knowledge is the knowhow and skills required for laboratory work.[23] Preparing and designing an experiment, a hands-on practical or experiment plan, implementing and evaluating a systematic and effective experiment are singled out as the most important competences of chemistry teachers.[24] For this reason, it is necessary to assess the extent to which teachers are capable of realising such curriculum requirements in practice.

The teachers consider traditional activities such as presenting curriculum contents and monitoring and checking students' achievements in accordance with

TABLE II. Teachers' answers to questions about the applicability of curriculum components for the realisation of teaching situations – questions Q10 and Q11 (N = 119)

Teaching situations	X	SD	Components of the curriculum							
			Goals and tasks of chemistry	Operative tasks/ out-comes	Con-tents	Demonstration experiments	Laboratory exercises	Instructions for realisation of a topic	Manner of realising curriculum	Additional work
2) Explaining and defining new concepts	4.08	0.91	26.1	41.2	39.5	23.5	19.3	19.3	12.6	8.4
6) Verifying the degree to which the subject matter taught in class has been learnt	3.96	0.88	26.9	41.2	21.8	10.9	13.4	5.9	17.6	5.9
7)Systematisation of the course contents	3.95	0.76	31.9	42.0	21.8	10.9	9.2	8.4	18.5[a]	3.4
1) Introducing a topic to students	3.93	0.84	49.6	26.9	37.8	21.8	14.3	19.3	14.3	4.2
13) Monitoring and assessing students' work	3.91	0.94	18.5	37.0	16.8	7.6	10.9	13.4	15.1	8.4
4) Organising laboratory exercises	3.77	1.15	16.8	17.6	10.1	19.3	46.2	15.1	15.1	5.9
3) Demonstration of experiments	3.75	1.03	11.8[a]	17.6	16.8	52.9	19.3	10.9	7.6	5.0
15) Using additional sources of knowledge (literature, the Internet...)	3.70	1.00	16.0	25.2	21.0	9.2	8.4	11.8	14.3	36.1
14) Assigning homework	3.70	0.92	16.0	31.1	24.4	4.2[a]	7.6	10.1	10.9	8.4
5) Demonstrating teaching aids	3.67	0.90	10.9	12.6[a]	18.5	19.3[a]	12.6	23.5	13.4	3.4
9) Organising individual work	3.61	1.01	10.1	16.8[a]	10.9	13.4	26.1	20.2	18.5	10.1
10) Acquisition of curriculum contents through problem solving	3.57	0.98	18.5	21.0	15.1	14.3	20.2	17.6	25.2[a]	20.2
8) Organising group work	3.56	0.94	12.6	17.6	14.3	14.3	26.9	22.7	26.1	10.1
12) Adjusting work to students with special needs	2.99	1.29	18.5	16.0	18.5	5.9	4.2	13.4	18.5	16.8
11) Project work	2.88	1.12	15.1	12.6	13.4	6.7	5.0	11.8	15.1	31.1

[a]Statistically significant differences between answers of teachers with different initial education

TABLE III. Answers of teachers with different initial education concerning translation of curriculum information into classroom activities

Activity/component	FC-TTP %	FC-NTTP %	ONTTP %	χ^2	*p*	Cramer V
Systematisation of curriculum contents /the manner of realisation of the curriculum	54.5	16.7	8.3	13.32	0.00	0.30
Acquisition of curriculum through problem solving/the manner of realising the curriculum	54.7	26.2	8.3	8.69	0.01	0.27
Demonstration of experiments/goals and tasks of chemistry	27.3	7.1	20.8	6.18	0.05	0.23
Demonstration of teaching aids/operative tasks - outcomes	36.4	13.1	0.0	9.12	0.01	0.28
Demonstration of teaching aids/demonstration of experiments	36.4	27.4	4.2	6.70	0.04	0.04

the established goals and outcomes of learning to be more applicable in practice than these activities that serve to fulfil contemporary requirements in teaching. This pertains to the application of contemporary work methods, the inclusion and presentation of new scientific achievements, adjustment to the context that refers to local and global levels, and also to the recognition of students' individual abilities. In such situations, more experienced teachers adjust their teaching more successfully, taking into consideration their students' abilities. However, experience is not a decisive factor when it comes to how much the competences of teachers are developed.[25] Thus younger teachers find more support in the curriculum for presenting the role of chemistry in various professions, which may be connected with the fact that they are better informed about the contemporary trends in science.

Apart from this, it was investigated how the teachers transform information from the curriculum to other activities that characterise good teaching practices, which are important both for chemistry and for all the other subjects being taught. The results of the teachers' answers are given in Table IV. The activities and results are classified based on the decreasing mean value for answers to question Q12.

The teachers who work in different kinds of schools and have different initial education did not manifest significant statistical differences in their assessments of the influence of the curriculum on the characteristics of their teaching practice. However, there are statistically significant differences between the assessments of the teachers with different working experience concerning the *recognition of individual abilities, predilections and the needs of students* (χ^2(1.104) = 20.02, p = 0.49) and seeing the role of chemistry in certain professions (χ^2(1.107) = 29.15, p = 0.02). According to the values for the Cramer V

TABLE IV. Teachers' answers to questions about the applicability of the curriculum for realisation of good teaching practices (N=119)

Chemistry curricula enable	1 Not at all	2 Negligibly small	3 Small	4 Mostly	5 Completely	X	SD
9) Students to continue education and for higher levels of education	0.0	3.7	5.6	50.0	40.7	4.28	0.73
1) Planning activities according to clearly defined teaching goals	0.0	3.8	7.7	62.5	26.0	4.11	0.70
18) Checking students' knowledge according to clearly defined learning outcomes	1.9	10.6	11.5	42.3	33.7	3.95	1.03
6) Linking curriculum contents with other natural sciences subjects	0.0	12.3	6.6	55.7	25.5	3.94	0.90
10) Students' continual self-education	0.0	8.7	14.4	53.8	23.1	3.91	0.85
16) Monitoring and evaluation of students' achievements	0.0	10.3	11.2	57.0	21.5	3.90	0.86
14) Seeing the role of chemistry in certain professions	0.9	10.3	14.0	51.4	23.4	3.86[a]	0.93
4) Acquisition of knowledge in keeping with students' age and previous knowledge	1.0	9.5	14.3	56.2	19.0	3.83	0.88
17) Application of clearly defined evaluation criteria	1.9	19.2	8.7	36.5	33.7	3.81	1.16
3) Teaching process featuring students in an active role	1.8	12.8	12.8	48.6	23.9	3.80	1.01
5) Acquisition of all necessary competences, knowledge, skills, views, values	1.0	9.5	16.2	56.2	17.1	3.79	0.87
7) Recognising the individual abilities, predilections and needs of students	1.0	13.5	19.2	39.4	26.9	3.78[a]	1.02
12) Inclusion and presentation of new knowledge and achievements	0.0	14.3	14.3	53.3	18.1	3.75	0.92
13) Adjusting the contents to subjects and grades	3.8	11.3	13.2	51.9	19.8	3.73	1.03
2) Application of contemporary work methods	0.9	14.2	15.1	54.7	15.1	3.69	0.93
15) Adjusting the contents to the technical, cultural and general level of social development	2.8	12.1	20.6	54.2	10.3	3.57	0.93
11) Adjusting the curriculum contents to the needs of the local environment	3.8	21.7	25.5	34.9	14.2	3.34	1.09
8) Inclusion of children with special needs	12.5	17.3	31.7	18.3	20.2	3.16	1.29

[a]Statistically significant differences between answers of teachers with different working experience

(0.50 and 0.52), this is considered to constitute a great influence.[26] The teachers with 20 years of working experience and more are of the opinion that the curricula mostly or completely provides a framework suitable for recognising the individual abilities of students through the teaching process. All the teachers with 5 to 10 years of working experience are of the opinion that the curricula mostly or completely enable the role of chemistry through certain professions to be seen.

Teachers' views on the necessary changes in the curricula

The teachers' views on the changes necessary in the curricula were also investigated. The teachers' competences, which include curriculum knowledge, should enable a critical view of the key documents for the realisation of teaching. For this reason, teachers are engaged during the course of reforms in order to give proposals for new curricula.[27] Within the framework of this survey, a detailed analysis of the curriculum was not expected, but an assessment of whether the information provided in the curriculum components is sufficient and specific enough for the planning and realisation of classroom work (Table V).

TABLE V. Teachers' answers (in %) to questions concerning changes in the contents of curriculum components (N = 119)

Curriculum components	Concretisation/reformulation/ developing the existing contents	Adding new elements	Excluding the existing contents
Goals and tasks of chemistry	71.4a	10.9a	3.4
Operative tasks/outcomes	58.0	26.1	3.4
Contents	37.8	27.7	17.6
Demonstration of experiments	41.2	38.7	2.5
Laboratory exercises	42.0	37.8	1.7
Instructions for the realisation of a topic	48.7	29.4	2.5
The manner of realising the curriculum	52.9	26.9	1.7
Additional work	37.8	39.5	5.0

[a]Statistically significant differences between answers of teachers with different working experience

There was a statistically significant difference between the views of the teachers with different working experience to the effect that, in the current curricula, it is necessary to concretise/reformulate/develop the existing goals and tasks of chemistry (χ^2(4.119) = 10.78, p = 0.03) and to add new goals and tasks (χ^2(4.119) = 10.56 p = 0.03). The teachers with less than 5 years working experience were the most in favour of the concretisation of the goals and tasks of chemistry (90.9 %). The percentage of such answers decreased the longer was the teachers' working experience, reaching up to 50.0 % among the oldest teachers. The teachers with more than 10 years of working experience differed from their younger colleagues in their request for adding new goals and tasks of chemistry.

The percentage of such answers increased with increasing working experience of the teachers (from 7.8 % to 31.2 %). These results indicate that the curricular knowledge depends on the length of the teachers' professional experience.

Curricular knowledge and an active attitude towards the curriculum on the part of teachers encompass their critical view of the structure and contents of the curriculum. Critical and analytical reviewing of the curriculum contributes to a greater ability of teachers to make the necessary decisions in their teaching on the basis of information from the curricular.[28] Moreover, in this way one obtains important feedback from teachers with practical experience about the quality of the curriculum, which is of importance for their future advancement. Teachers should understand the curriculum material as their professional means of work, and should learn, through education and professional development, about curricula and from them.[29]

CONCLUSIONS

The competences of chemistry teachers, a set of knowledge and skills needed to perform an activity, comprise, among other things, curricular knowledge. Translation of information from the curriculum into corresponding teaching situations, tasks for students, *i.e.*, activities in the classroom, requires knowledge of the nature of the contents being taught to students and the nature of the problem of forming certain concepts, then knowledge of the characteristics of certain methods of teaching and learning, the characteristics of the age group of the students that a teacher is working with, their interests and possible adjustments. The translation is also connected with planning the resources required for the realisation of teaching according to the curriculum (the materials for experiments, special teaching aids, printed and electronic materials, *etc*.). The entire teaching process depends on how teachers translate curriculum requirements into a form that students can understand and acquire.

The results of this survey show that the teachers are not aware of all the roles and the importance of certain curriculum components. Furthermore, it was perceived that information from certain components remains unused even though it is relevant to a certain level of planning (for example, about demonstration experiments and laboratory exercises, for the purpose of the annual planning of the overall funds required for teaching during one school year).

Teachers' professionalism encompasses autonomy and responsibility. The important question here is what autonomy means in relation to the curriculum, how a teacher uses information from the curriculum as a framework for various adjustments that teaching requires in a particular context (according to previous knowledge, interests and other needs of students, the available means at school, the requirements of the profession that students are preparing for, the needs of the local environment and society in general). Autonomy comprises deciding which methods to use in order to realise teaching in keeping with the envisioned contents, the goals and outcomes in the curriculum. It also comprises deciding on how to set up a demonstration experiment, how to organise laboratory practice (individual or group work), and the like. A teacher's responsibility is reflected in his/her acknowledgement of information from the curriculum, professional assessment of the relevance of the information from some components for the planning and realisation of teaching.[30] Within the sample of teachers encompassed by this survey, it turned out that the goals and operative tasks/outcomes are the most important curriculum component for the teachers' work.

A well prepared chemistry teacher should apply and evaluate the curriculum. He/she attains the ability to do so by acquiring general curriculum knowledge, knowledge of the chemistry curriculum, and by forming a professional attitude towards the curriculum. The acquisition of such knowledge and the development of an active and professional attitude towards the curriculum should be included in teachers' initial education and further developed through programmes of continual professional development. The indicators of teachers' curricular knowledge are their understanding of the purpose and role of this document in the planning of teaching, the manner of applying the information contained in the curriculum and the evaluation of the quality of the curriculum. An important issue for the interpretation of the curriculum are a teacher's beliefs: beliefs about the goals or purposes of science teaching, beliefs about the nature of science and beliefs about science teaching and learning.[31]

Research has shown that there is not enough literature that could help teachers to understand the documents, instructions and materials according to which they should work,[32] and that there are few papers aimed at the manner of realising a great number of the prescribed standards.[33–35]

The survey realised provides a basis for defining indicators for monitoring the ability of teachers to apply curricular knowledge in their practice. Such indicators are important for creating tasks in the initial education of teachers, through which curricular knowledge is developed, tasks for teachers' professional development and for monitoring teachers' progress and planning activities which could improve curriculum knowledge.

A limitation of this survey is that monitoring was based on a teacher's personal assessment that could lead to attempts to give an answer that is considered desirable. Future surveys will include research methods of direct assessment of the degree and application of a chemistry teacher's knowledge of curricula.

SUPPLEMENTARY MATERIAL

The Questionnaire is available electronically from http://www.shd.org.rs/JSCS/, or from the corresponding author on request.

Acknowledgements. This paper represents a result of work within the project "Scientific Theory and Practice in Society: Multidisciplinary, Educational and Inter-generational Perspectives", Project No. 179048, the realisation of which was financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

ИЗВОД

ЗНАЊЕ СРЕДЊОШКОЛСКИХ НАСТАВНИКА О НАСТАВНИМ ПРОГРАМИМА ХЕМИЈЕ

БИЉАНА ТОМАШЕВИЋ и ДРАГИЦА ТРИВИЋ

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У овом истраживању испитивано је професионално знање наставника хемије о структури, садржају и примени наставних програма хемије и њихових компоненти. Истраживањем је обухваћено 119 наставника из 69 средњих школа (25 гимназија и 44 средње стручне школе). Питања упитника односила су се на опште знање о наставним програмима, знање о наставним програмима хемије и на ставове о неопходним изменама у актуелним програмима. Одговори наставника показују да су за њихов рад најзначајније компоненте програма циљеви и оперативни задаци/исходи. Уочено је да информације из одређених компоненти остају неискоришћене иако су релевантне за одређени ниво планирања. Међу наставницима у узорку, они који имају иницијално образовање за наставничку професију у већем проценту су примењивали информације из наставног програма у реализацији наставе демонстрационом методом и методом учења путем решавања проблема. Изведено истраживање пружа основ за дефинисање индикатора за праћење оспособљености наставника да примењују знање о наставним програмима у својој пракси. Такви индикатори су значајни у креирању иницијалног образовања наставника и програма за њихов професионални развој.

(Примљено 2. октобра, ревидирано 7. децембра, прихваћено 8. децембра 2014)

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