

Initial Beliefs of Preservice Chemistry Teachers in Croatia

LANA ŠOJAT¹

∞ In the past thirty years, there have been many political changes in Croatia. These changes have had an impact on the education system, as well. The success of such educational changes depends on the teacher. The importance of teachers' knowledge and their beliefs about teaching and learning for their action in the classroom is well known. Beliefs influence teachers' representation of science, science knowledge and the organisation of knowledge and information. Keeping teacher professional development in mind, preservice teachers' beliefs need to be sought out and examined by educators. These beliefs should be developed in the direction of teaching chemistry taking into account recent reforms, as well as teaching and learning theories. Various studies have been undertaken in different education backgrounds and systems regarding the beliefs of both preservice and in-service teachers. These studies show different results depending on the context in which they are undertaken. Transferring data to the Croatian system is therefore difficult. However, there are no studies in Croatia focusing on the teachers' beliefs regarding teaching and learning chemistry. The present study evaluates the initial beliefs of preservice chemistry teachers in Croatia. The participants were instructed to draw themselves as chemistry teachers in a typical classroom situation in chemistry, and to answer four open questions. Data analysis follows a pattern representing a range between the predominance of more traditional orientations versus more modern teaching orientations, in line with educational theory focusing on: 1) beliefs about classroom organisation, 2) beliefs about teaching objectives, and 3) epistemological beliefs. The data revealed mostly traditional and teacher-centred knowledge among all of the participants. In the present paper, the data will be discussed and the implications for Croatian chemistry teacher training will be established.

Keywords: initial teacher education, preservice teachers' beliefs, teacher professional development

1 7th Grammar School Zagreb, Croatia; lana.saric2712@gmail.com.

Prepričanja študentov študijskih programov izobraževanja učiteljev kemije na Hrvaškem

LANA ŠOJAT

∞ V zadnjih tridesetih letih je bilo na Hrvaškem veliko političnih sprememb. Te so vplivale tudi na izobraževalni sistem. Uspeh sprememb na področju izobraževanja pa je odvisen od učiteljev. Znano je, da imata na učiteljevo delovanje v razredu velik vpliv njegovo znanje ter prepričanje o poučevanju in učenju. Prepričanja vplivajo na učiteljevo predstavljanje naravoslovja, naravoslovnega znanja ter na organizacijo znanja in informacij. Upoštevač poklicni razvoj učiteljev, je treba ugotavljati in preučevati prepričanja študentov študijskih programov, ki se izobražujejo za učitelje. Ta prepričanja bi morala biti razvita v smer poučevanja kemije, upoštevač nedavne reforme pa tudi teorije poučevanja in učenja. Različne raziskave so bile izvedene v različnih izobraževalnih kontekstih in sistemih glede na prepričanja študentov študijskih programov izobraževanja učiteljev pa tudi učiteljev iz prakse. Raziskave kažejo različne rezultate, odvisno od konteksta, v katerem so bile izvedene. Prenos podatkov v hrvaški sistem je zato težaven, vendar na Hrvaškem ni raziskav, ki bi se osredinjale na prepričanja učiteljev glede poučevanja in učenja kemije. V prispevku preučujemo začetna prepričanja študentov študijskih programov izobraževanja učiteljev kemije na Hrvaškem. Udeleženci so dobili navodilo, da se narišejo kot učitelji kemije v tipičnem razredu pri pouku kemije in odgovorijo na štiri odprta vprašanja. Analiza podatkov sledi vzorcu, ki predstavlja razpon med prevlado tradicionalnih usmeritev nad sodobnejšimi učnimi usmeritvami skladno z edukacijsko teorijo, ki se osredinja na: 1) prepričanja o organizaciji učilnic; 2) prepričanja o učnih ciljih; 3) epistemološka prepričanja. Podatki vseh udeležencev raziskave kažejo večinoma tradicionalne in na učitelja osredinjene načine poučevanja. V prispevku razpravljamo o rezultatih in ugotavljamo njihovo mogočo uporabo v hrvaških študijskih programih izobraževanja učiteljev kemije.

Ključne besede: študijski programi izobraževanje učiteljev, prepričanja študentov študijskih programov izobraževanja učiteljev, profesionalni razvoj učiteljev

Introduction

Teachers' Beliefs in Science Education Research

Research on beliefs provides a better understanding of humans thought patterns and actions. According to Thompson (1992), the first attempts to research beliefs can be observed at the beginning of the twentieth century, and they become a prominent issue in science education and research in the late 1980s, as cited in Markic (2008). The strong influence of behaviourism shifted the focus from the beliefs in earlier years. In later years, however, the turn away from behaviourism towards constructivism (Kang & Keys, 2000) put beliefs, as well as research about them, back in focus as a point of interest.

Nespor (1987) characterises beliefs as strongly affective and evaluative, deeply personal, stable and lying beyond the individual's controlled knowledge, unaffected by persuasion. According to him, beliefs create an ideal or alternative situation that may sometimes differ from reality; they are rooted deep in vivid memories of experience from the past. As cited in Markic (2008), Nespor speaks of "critical experience" that "[...] produces a richly-detailed episodic memory which later serves the student as an inspiration and a template for his or her own teaching practice" (p. 320). The formation of beliefs based on personal experience is also supported by O'Loughlin and Campbell (1988). Beliefs are defined as psychologically held understandings, premises or prepositions about the world that are felt to be true (Richardson, 2003).

Thus, in the continuation, the definition of beliefs will be adapted from Markic (2008), who claims that:

- *beliefs are separate from knowledge,*
- *beliefs refer to all mental representations that teachers or student teachers hold (consciously and unconsciously) in their minds that influence, to a certain extent, their (potential) behaviour as teachers of science,*
- *"all beliefs are personal constructs influenced by experience, knowledge, and societal backgrounds." (Markic, 2008, p. 11)*

Teachers play a crucial role in changing classroom reality and supporting the success of different education reforms (De Jong, 2007). They are the binding component of a chain reaching from the ministry of education, to school textbooks and students. Teachers should be the starting point of any changes in the education system. The question is: What influences/affects teachers' actions in the classroom?

In researching the influence of the teacher on their activities in the classroom, different foci are taken. Teachers' practical knowledge consists of *knowledge* and *beliefs* combined with interactive cognition (Meijer, Verloop, & Beijaard, 2002). However, beliefs and knowledge can sometimes be mixed or misinterpreted. The similarities of both terms are pointed out by Anderson (1980): both knowledge and beliefs are experienced acquired information that continues in a person's mind. Nespør (1987), on the other hand, separates these two terms and sees beliefs as a framework for systematic and comparative investigations of teaching. A summary of the characteristics of and differences between beliefs and knowledge, as discussed in the literature (see Savasci-Acikalin, 2009), is given in Table 1. While beliefs seem to be well defined and focus on one direction, teachers' knowledge seems to be more differentiated.

Table 1

Differences between teachers' beliefs and knowledge

Beliefs	Knowledge
Refer to suppositions, commitments and ideologies	Refers to factual propositions and understandings that inform skilful action
Do not require a truth condition	Must satisfy the "truth condition"
Are based on evaluation judgment	Is based on objective fact
Cannot be evaluated	Can be evaluated or judged
Are episodically stored material influenced by personal experiences or cultural and institutional sources	Is stored in semantic networks
Are static	Often changes

Note. Adapted from Savasci-Acikalin, 2009, p. 4.

Teachers' beliefs influence how they represent science in general, and chemistry in particular, in their classrooms and the kinds of opportunities they provide for students to learn (Roth et al., 2006). They are the best indicator of one's behaviour, actions and decision making (Bandura, 1986). Beliefs influence the interactions between teachers and their students, as Koballa, Gräber, Coleman and Kemo (2000) conclude, adding that teachers' beliefs about teaching and learning always include aspects of beliefs exclusive to their chosen discipline or subject. Beliefs play an important role in how teachers organise knowledge and information and are essential in helping them to adapt, understand and make sense of themselves and their world (Schommer, 1990).

Beliefs are sometimes represented as a bridge between a person and the environment (Pajares, 1992; Törner, 2002). They can also be compared to "old

clothes” (Schommer-Aikins, 2004, p. 22): they become more comfortable with time and use. This is sometimes an obstacle, inhibiting the necessary change in beliefs of some people. For these reasons, teacher education must work with the beliefs that guide teachers’ actions (behaviour) with the principle and evidence that underlie the choices teachers make (Shulman, 1987). A synthesis of findings on beliefs was made by Pajares (1992, pp. 324–326), as follows:

- Beliefs are formed early on and tend to be self-eternalised. They tend to be preserved throughout time, experience, reason and schooling.
- People develop a belief system that contains all of the beliefs attained through the process of cultural transmission.
- Beliefs are prioritised according to their link or relationship to other beliefs.
- The earlier a belief is incorporated into the belief system, the more difficult it is to change.
- Modification of beliefs is relatively rare during adulthood.
- Beliefs are strongly influenced by perceptions.
- The beliefs individuals possess strongly affect their behaviour.
- Beliefs about teaching are well established by the time a student attends college.
- Beliefs play a key role in defining tasks and selecting the cognitive tools used to interpret, plan and make decisions regarding such tasks.

In the past ten years, the focus of science education research has moved to teachers’ and student teachers’ beliefs (De Jong, 2007). Five interrelated research zones (Calderhead, 1996) are differentiated:

1. Beliefs about learners and learning.
2. Beliefs about teaching.
3. Beliefs about the subject.
4. Beliefs about learning how to teach.
5. Beliefs about “self” and the teaching role.

Preservice teachers commence their teacher training with the set of beliefs they (un)consciously possess. These beliefs are often based on their earlier experience (Markic & Eilks, 2008; Smith, 2005) and they influence their view of the relevance and usefulness of teacher education training. In order to overcome initial (traditional) beliefs, teacher education training must initiate changes through its courses (Choi & Ramsey, 2010).

There is no doubt that the beliefs of preservice and in-service teachers should be the focus of research in the field of science education. In the last

thirty years, there has therefore been a significant increase in interest in beliefs in both general and science education (De Jong, 2007). In the literature, various studies can be found about science (student) teachers' beliefs regarding teaching and learning (e.g., Buldur, 2017; Bursal, 2010; Hamilton, 2017; Markic, 2008; Markic & Eilks, 2013). However, these studies have been carried out in different educational backgrounds and systems, with political systems, cultures and religions that are incomparable in most cases. Studies like that by Al-Amoush, Markic, Usak, Erdogan and Eilks, (2014), comparing beliefs about teaching and learning held by chemistry teachers from different countries, reveal significant differences. Similarities can be found in a study by Cakiroglu, Cakiroglu and Boone (2005), conducted on a sample of Turkish and American preservice teachers. In their study, Uzuntiryaki, Boz, Kirbulut and Bektas (2010) show that preservice teachers lack beliefs about constructivism in science teaching. The tendency towards a more constructivist approach to science teaching is demonstrated by experienced teachers rather than beginners (Caleon, Tan, & Cho, 2018). Bryan (2012) presents a review of research on the beliefs of prospective and practising science teachers. With time, under the influence of a teacher training programme or reform initiative, beliefs are influenced. Epistemic beliefs have a significant role in defining different types of teaching knowledge among preservice teachers (Greene & Yu, 2016). They also have an influence on the practice (Brownlee, Schraw, & Berthelsen, 2011; Lunn Brownlee, Ferguson, & Ryan, 2017) and future classrooms of these teachers (Feucht, 2010; Schommer-Aikins, 2004). Furthermore, studies such as those by Alexander (2001), Markic et al. (2016) or Woolfolk-Hoy, Davis and Pape (2006) reveal differences between teachers from different cultural backgrounds within one country.

In Croatia, research on chemistry education is still in its early stages. Vladusic, Bucat and Ozic (2016a) have undertaken research on the understanding of chemical bonding by participants at all levels of the chemical education system in Croatia. The existence of alternative conceptions is noted at all levels of education, but the PCK (pedagogical content knowledge) of teachers cannot be based on an inadequate level of content knowledge. A study on students' understanding of scientific words and representations and everyday words used in chemistry teaching (Vladusic, Bucat, & Ozic, 2016b) indicates considerable differences in the extent of understanding from word to word and symbol to symbol. Although some of the findings are in line with other studies (English-speaking countries), there are some differences specific to the Croatian language (similar sounding words with different meanings, words with different meanings in everyday life and the science context). Research on the use of particulate drawing (Simicic, 2018) in analysis learning, testing and the

improvement of conceptual knowledge in initial chemistry teaching found that progress was noticeable in both a control group and a treatment group, with no statistically significant difference. The students in both groups were taught by the same methodical approach, with a slight difference in the use of particulate drawing in the treatment group only. After the instruction, the misconceptions were partly retained, but considerably less so in the treatment group. There is no research about chemistry teachers' beliefs for either preservice or in-service teachers.

Teachers' Beliefs and Curriculum Reforms

In general, teachers' deeply held beliefs need to be sought out by teacher educators in order to provide student chemistry teachers with ample opportunities to create teaching and learning aligned with recent reforms. Preservice teachers' beliefs need to be developed in a direction that ensures that chemistry will be taught according to recent teaching and learning theories. Fenstermacher (1979) argued that one goal of teacher education is to help young teachers transform tacit or unexamined beliefs about teaching, learning and the curriculum into objectively reasonable or evidentiary beliefs. In teacher education, preservice and in-service teachers' beliefs should be a central focus for teacher educators in order to challenge belief systems about teaching and learning. Research into the beliefs of in-service and preservice teachers is very important, yet such beliefs are an insufficiently explored field in science education research, especially in Croatia. Many initial beliefs do not mirror modern educational theories, and teacher educators should raise the awareness of the initial beliefs and preconceptions held by preservice teachers (Bryan & Atwater, 2002). In most Croatian schools, teaching is still based on traditional views. Traditionally orientated in-service teachers (in)directly influence students who are potential future pre-service teachers, affecting their beliefs, as well. Teaching and learning should be student-oriented with students as the central point of the teaching and learning process. There is therefore a need for change at all levels of education.

Reforms in the Croatian Education System

Since the 1990s and the war in Croatia, many political and structural changes have been made. These are evident in the education system, as well. In the past decade, and especially in the past five years, there has been an urgent need for a new, more western-world-oriented education reform. In the past

almost thirty years, chemistry has been a mandatory subject in in the final two years of primary school (grades 7 and 8, age 13–15). In secondary school, the inclusion of chemistry depends on whether it is a grammar school (all four years, ages 15–18/19) or vocational school (one or two years for non-chemist vocation, four years for vocation connected with chemistry with a special emphasis on certain typical chemistry knowledge).

Some basic knowledge about matter, atoms, chemical reactions and the basics of organic chemistry are gained in primary school. In secondary school (grammar school), chemistry is divided into general chemistry (1st grade), through physical and inorganic chemistry in the 2nd and 3rd grades, to organic chemistry with the basics of biochemistry in the final year. Although there are connections and interweaving of content, the curriculum – mainly in secondary school – is focused on memorisation and does not link the content with, for instance, social and environmental issues. Teaching chemistry in secondary school (grammar school) is often subject to the pressure of the National Graduation Exam or the university entrance exam.

A new education reform (Jokic, 2016) has been presented in the last few years. Since September 2018, it has been applied in a minority of schools as an experiment, but it is scheduled for implementation in September 2019. From the standpoint of chemistry, this concerns the 7th grade in primary schools and the 1st grade of grammar schools in the territory of Croatia. Chemistry is presented as a mandatory subject in primary school (7th and 8th grade) and the first three years of secondary school. In the final year of secondary school, chemistry is an optional subject for students who plan a career in the area of science. The content is divided into three chemistry macro concepts: (i) Matter, (ii) Chemical Process and Changes, and (iii) Energy, all of which are united in Scientific Literacy (Bybee, 1997). The inquiry-based approach is seen as the main resource for acquiring knowledge, and the experiment is the foundation for gaining new knowledge, which should be integrated into existing knowledge (Gormally, Brickmann, Haller, & Armstrong, 2009). The curriculum is conceived as a spiral, with concepts being upgraded every year, and teaching should be student-centred. There is no change in the number of classes per week (primary school and the first three grades of secondary school, while the number of classes is still not determined for the final year), but it is possible to have chemistry classes once per week (90 minutes) rather than twice per week (45 minutes).

The main characteristics of the “old” and “new” curriculum (primary and grammar school) are given in Table 2.

Table 2
Characteristics of both curricula

	Old Curriculum	New Curriculum
Obligatory	7 th and 8 th grade of primary school 1 st –4 th grade of secondary school	7 th and 8 th grade of primary school 1 st –3 rd grade of secondary school 4 th grade optional (secondary school)
Primary School	<ul style="list-style-type: none"> • matter and its properties • chemical reactions • atom and PTE • chemical kinetics • basics of organic chemistry and biochemistry (hydrocarbons, carboxylic acid, alcohol, esters, carbohydrates, proteins) • ecological themes 	3 macro concepts: Matter, Energy and Chemical Process: <ul style="list-style-type: none"> • matter and its properties – accent on practical work • chemical reactions • atom and PTE • basics of organic chemistry • ecological themes • everyday life chemistry Scientific Literacy
Secondary School	1 st year: general chemistry (atomic structure, bonds, basics of stoichiometry) 2 nd year: physical chemistry (thermochemistry, liquids, solutions, kinetics, equilibrium, acids, bases and salts) 3 rd year: electrochemistry, periodic table – groups 1, 2, 14, 15,16, 17, Fe, Al, Cu – main characteristics and properties 4 th year: organic chemistry (hydrocarbons, organic compounds with oxygen and nitrogen, basics of biochemistry)	3 macro concepts: Matter, Energy and Chemical Process: <ul style="list-style-type: none"> • 1st year (atomic structure, bonding, properties of liquids and gases, stoichiometry) • 2nd year (thermochemistry, solutions, kinetics, basics of organic chemistry, main characteristics of metals and non-metals) • 3rd year (electrochemistry, acids, bases and salts, chemical equilibrium) • 4th year (optional choice of 3 main topics out of 6 offered) Scientific Literacy Cross-Curriculum Topics (ICT, Health and Care, Ecological Themes, Sustainable Development, etc.)
Evaluation	Oral exam, written exam, practical usage of knowledge	Adoption of chemical concepts Scientific Literacy

In comparing the differences between the old and new curricula with regard to teaching chemistry in Croatia, the question arises as to whether future chemistry teachers in Croatia are ready and prepared for implementing such a reform, which follows different and – for the teachers – new goals. However, no studies have been undertaken in Croatia focusing on preservice teachers' beliefs about teaching and learning chemistry, and showing how preservice teachers' development is compatible with the development of education and new educational theories.

The first step is to make both preservice and in-service teachers aware of the existence of beliefs, making beliefs explicit and discussing them. Preservice teachers in Croatia are not yet aware of the existence of beliefs or their effect on future teaching methods. The beginning of science education courses is a good starting point for making preservice teachers aware of the existence of

preconceptions and beliefs that can influence their future teaching methods. The present study is focused on answering the following research question: *What beliefs about chemistry teaching and learning do Croatian preservice chemistry teachers hold at the beginning of their university teacher training?*

Method

Instrument

Due to the various difficulties that can be encountered (hesitation in expressing unpopular or undesirable beliefs, language issues, etc.), there are different instruments available for researching teachers' beliefs (Wehling & Charters, 1969). A list of instruments for the evaluation of teachers' beliefs is given by Markic (2008). Greater insight into teachers' beliefs is provided by a qualitative rather than a quantitative method (Lederman, 1992). Among the potential deficiencies of the instrument reported by Fischer (2001) are an inability to demonstrate a connection between beliefs and practice, and the inflexibility of evaluation due to the limitation of written text.

A good solution for taking a snapshot of (preservice) teachers' beliefs is image making and drawing (Wilson & Wilson, 1979), through which teachers' identities, as shaped and developed by years of many and varied influences, can be evaluated (Markic & Eilks, 2014). The participants in the present study were instructed to draw themselves as chemistry teachers in a typical classroom situation in their chosen subject and to answer four open questions: (i) What is the teacher doing? (ii) What are the students doing? (iii) What are the objectives of the teaching in the presented situation? (iv) What happened prior to the drawn teaching situation? This idea relates to the "Draw-A-Science-Teacher-Test Checklist" (DASTT-C) (Thomas, Pedersen, & Finson, 2001), supplemented with questions about teaching objectives and prior activities. Data analysis was undertaken following the evaluation pattern described by Markic (2008). The evaluation pattern, based on three categories, represents a range between the predominance of more traditional versus more modern teaching orientations in line with educational theory. Three 5-step scales focus on:

1. Beliefs about Classroom Organisation
2. Beliefs about Teaching Objectives
3. Epistemological Beliefs

The validity of the data was achieved through independent rating and searching for inter-subjective agreement (Swanborn, 1996). The rating of

preservice teachers' drawings and responses was done by science education experts and teachers. The evaluation pattern does not present linear scales; the numbers are symbols for the descriptions that are made along with the data. A short description of the three categories is presented in Table 3.

Table 3

An overview of the three scales

	Traditional View		Modern View
Beliefs about Classroom Organization	Classroom activities are mostly teacher-centred, directed, controlled and dominated by the teacher.	↔ -2, -1, 0, 1, 2	Classes are dominated by student activity and students are able to choose and control their activities.
Beliefs about Teaching Objectives	Science teaching is more or less exclusively focused on content learning.	↔ -2, -1, 0, 1, 2	Learning of competencies, problem-solving or thinking in relevant contexts are the main focus of teaching.
Epistemological Beliefs	Learning is passive, directed and controlled by the dissemination of knowledge.	↔ -2, -1, 0, 1, 2	Learning is a constructivist, autonomous and self-directed activity.

Note. Adapted from Markic, 2008.

The suggested terms *traditional beliefs* (transmission-oriented beliefs of learning with a focus on pure subject-matter knowledge) and *modern beliefs* (beliefs based on constructivist learning, student-oriented classroom structures and an orientation towards more general educational skills, including Scientific Literacy for all) are based on Grounded Theory, as stated in Markic and Eilks (2008).

Examples of preservice teachers' drawings are given in Figure 1. Both pictures represent a chemistry class in the 1st grade of secondary school. The drawing on the left (a) indicates the strong traditional beliefs of this preservice teacher, even with certain scientific misconceptions. The students are not working in groups and the teacher is explaining the shape of a water molecule (while the students listen carefully, as stated in the remark). The picture on the right (b) is from a preservice teacher who holds more modern beliefs. The students are learning about mixture separation through hands-on experiments. The groups are rotating so that the students get to know different ways of separating the mixtures. On the teachers' table is a demonstration experiment (distillation).

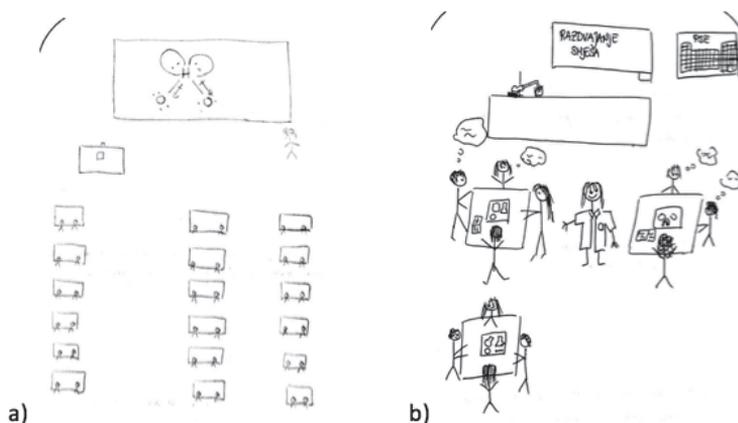


Figure 1. Examples of preservice chemistry teachers' drawings (DASST-C)

Sample

The study was conducted in 2016 and 2017 on a sample of 50 female Croatian preservice teachers aged between 21 and 26 years. Being a teacher in Croatia is traditionally regarded as a female occupation. The preservice teachers are from the Faculty of Science of three different Croatian universities: the Universities of Osijek (11 participants), Split (12 participants) and Zagreb (27 participants), which are currently the only universities in Croatia offering programmes in chemistry teacher education. In Croatia, there are two different types of study programmes for becoming a chemistry teacher. Their main characteristics are given in Table 4.

Table 4

Differences and similarities between teacher training programmes

	A	B
Differences	<ul style="list-style-type: none"> chemistry and another scientific domain teacher both subjects studied at the bachelor level no bachelor thesis Master of Education in Chemistry and either Biology or Physics 	<ul style="list-style-type: none"> chemistry teacher focus on pure chemistry at the bachelor level Bachelor of Science (B.Sc.) Master of Education in Chemistry (M.Sc.)
Similarities	<ul style="list-style-type: none"> duration: 5 years first year of master's study: two-semester chemistry education module – seminar and lecture character (1st semester) and 120 hours of internship (2nd semester) 	

Data were collected before the science education courses commenced, in order to evaluate the beliefs of the preservice teachers to which science teacher educators need to be attentive during their lessons and seminars. The sample is representative, as the data were collected from all of the preservice chemistry or chemistry and biology/physics teachers attending A and B study programmes in Croatia at all three universities.

Results

The presented data were analysed in terms of the three categories (Table 3). The majority (almost 90%) of preservice chemistry teachers in Croatia hold more traditional beliefs about classroom organisation. For 27.5% of the participants, the teacher dominates throughout the learning process and is the centre of any activity. The majority of preservice chemistry teachers hold beliefs that are rather teacher-centred, with slight interaction with the students (-1). A rather low percentage of preservice teachers have neither teacher-centred nor student-centred beliefs about classroom organisation (0 stands for balanced teacher-centred and student-centred activities). At the beginning of their science education courses, just 5.8% of preservice teachers have rather student-centred beliefs (at the core are student activities initiated and controlled by the teacher). None of the participants hold strongly student-centred beliefs (2).

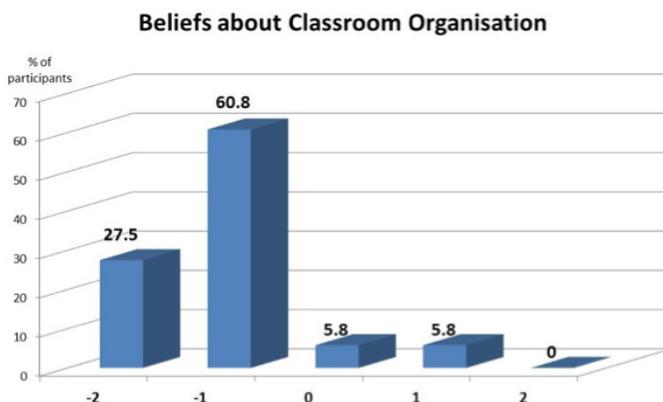


Figure 2. Beliefs about Classroom Organisation

Beliefs about teaching objectives (Figure 2) revealed a slightly more heterogeneous distribution, although most of the preservice teachers' beliefs (52.9%) were exclusively traditional and oriented towards content structure:

learning of facts is the central objective. Approximately the same percentage of participants hold either rather content-structure oriented beliefs (-1): the focus is on the learning of facts, with some non-cognitive objectives targeted; or neither content-structure nor scientific literacy oriented beliefs (0): there is a balance in learning content and applications/non-cognitive objectives, and motivational objectives are at the core. Before the science education training started, only 5.8% of the participants demonstrated beliefs that are slightly modern: learning competencies, problem-solving and thinking in a relevant context. None of the participants hold strongly scientific literacy-oriented beliefs about teaching objectives.

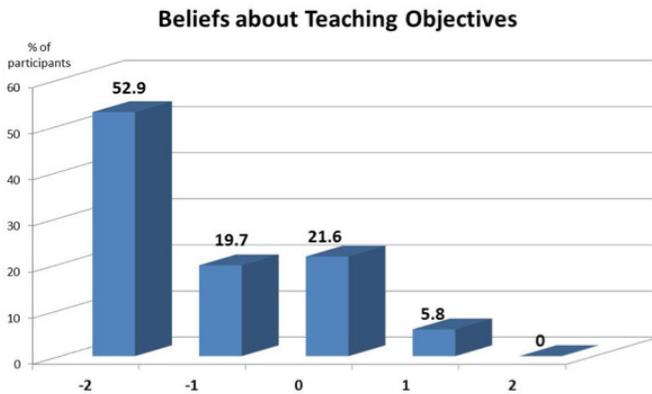


Figure 3. Beliefs about Teaching Objectives

More than 90% of the participants hold traditional epistemological beliefs, as shown in Figure 3. A slight shift can be seen from passive and over-directed learning, whose main goal is the dissemination of information/receptive learning (-2), towards over-directed learning with a student-active phase (learning is followed by a storyboard written, organised and directed by the teacher, but conducted by the students). Only 3.9% of the participants take into consideration the students' preconceptions when planning the learning process, which is still over-directed. Rather constructed learning (autonomous and self-directed learning initiated and partly directed by the teacher) is demonstrated by 5.8% of the preservice chemistry teachers, while none of the participants hold beliefs that include strongly constructive learning.

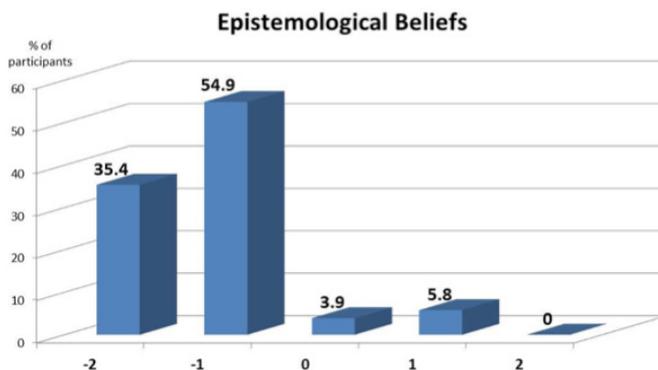


Figure 4. Epistemological Beliefs

A homogenous distribution can be observed within all three dimensions: epistemological beliefs, as well as beliefs about classroom organisation and teaching objectives, are more or less teacher-centred. The majority of preservice teachers in Croatia view learning chemistry as the teacher organised and directed transmission of knowledge. This traditional teacher-centred view is not oriented towards problem-solving and gaining competencies for today's (science) world through student-centred constructive learning, but rather towards learning science content structure and facts through receptive or over-directed learning.

The combination of coding from each category was made for each participant in order to explore the mutual equality of the three categories. Figure 4 shows the sum of the combinations. When the student teacher rating is closer to the upper, rear corner of the diagram, the preservice chemistry teacher holds more modern and student-centred beliefs. The opposite is the case for student teachers placed in the lower, front corner of the diagram: the beliefs that the students hold are more traditional and teacher-centred.

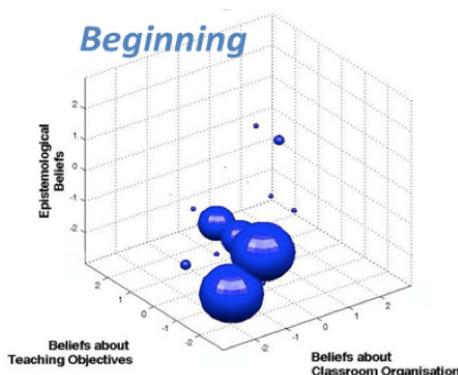


Figure 5. 3D representation of the data.

The size of the bubbles represents the number of preservice teachers.

Discussion, implications and conclusions

Beliefs about classroom organisation and epistemological beliefs are traditional rather than modern, but with a tendency towards modern beliefs. The majority of preservice teachers see themselves as the centre point of classroom activities, either as the dominant figure in the teaching process or the disseminator of information in the learning process. On the other hand, beliefs about teaching objectives are either strongly traditional and oriented towards learning the content of the subject, or located between a mild content orientation with some non-cognitive objectives and a balance between learning content and non-cognitive objectives. At this point of the study (the beginning of the teacher training courses), the majority of the preservice teachers have a code combination in the front lower part of the diagram (Figure 4), i.e., they hold rather traditional beliefs about all three categories.

Croatian preservice chemistry teachers' beliefs are very homogeneous, regardless of the university they attend. They hold more traditional beliefs about teaching and learning. It can be assumed that preservice teachers are influenced by their own experience as students in primary and/or secondary school. They reflect their own impressions based on traditional beliefs regarding teaching and learning. This indicates that the teaching and learning in the majority of Croatian schools was (and probably still is) more teacher-centred, so it is no surprise that the beliefs at the starting point of the research are traditional, as well. It is possible that the preservice teachers will develop another style of teaching after the teacher training course. This can be examined in a later study.

The present study suggests that the content of teacher training must focus on detection of preservice teachers' beliefs and making these beliefs explicit. Teacher training of preservice chemistry teachers must be grounded in modern educational theories: modern goals of chemistry lessons and student-centred methods in teaching and learning. Since teachers' beliefs influence their representation of science in the classroom and impact teacher-student interaction, they need to be sought out and made explicit. All teachers (preservice, in-service and university teachers) must be aware of the existence of beliefs and their influence on the way they organise knowledge and information, so that the teachers can, as Schommer (1990) remarks, make sense of themselves, as mentioned earlier. Since in-service teachers have an influence on the teaching styles and methods of preservice teachers, the focus should be on their beliefs, as well, through in-service teacher training.

As shown by this study, preservice chemistry teachers in Croatia hold rather traditional beliefs about teaching and learning at the beginning of their

teacher training courses. There is a need to develop student-centred, constructivist-oriented and modern ways of teaching chemistry. This is in line with the new education reform that is in progress. But are preservice teachers, as well as in-service teachers, ready for new and different goals? Change is needed in the Croatian education system, not only at the primary and secondary level, but in university teacher education, as well. It would be possible to study in-service teachers' beliefs in terms of their years of experience, for instance. Workshops based on making teachers aware of their beliefs would be a good starting point for further study of Croatian chemistry teachers' beliefs. A longitudinal study of the same group of preservice chemistry teachers during their teacher training course as well as their in-service years would be possible. For an in-service teacher, the beginning of teacher training courses is a good starting point for the first step in dealing with beliefs.

More emphasis should be placed on making teachers, both preservice and in-service, aware of their beliefs, encouraging them to discuss them openly and work on making them more modern, thus fostering student-centred and constructivist-oriented ways of teaching chemistry in order to follow the new education reform. These must rely on the anticipated goals of the education reform.

References

- Al-Amoush, S., Markic, S., Usak, M., Erdogan, M., & Eilks, I. (2014). Beliefs about chemistry teaching and learning – a comparison of teachers and student teachers beliefs from Jordan, Turkey and Germany. *International Journal of Science and Mathematics Education*, 12(4), 767–792.
- Alexander, R. J. (2001). *Culture and pedagogy: International comparisons in primary education*. Malden, MA: Blackwell Publishers.
- Anderson, J. R. (1980). *Cognitive psychology and its implication*. San Francisco, CA: Freeman.
- Bandura, A. (1986). *Social foundation of thought and action: A social cognitive theory*. Englewood, NJ: Prentice-Hall.
- Brownlee, J., Schraw, G., & Berthelsen, D. (2011). (Eds.). *Personal epistemology and teacher education*. New York, NY: Routledge.
- Bryan, L. A., & Atwater, M. M. (2002). Teacher beliefs and cultural models: A challenge for science teacher preparation programs. *Science Education*, 86 (6), 821–839.
- Bryan L. A. (2012). Research on science teacher beliefs. In B. Fraser, K. Tobin, & C. McRobbie (Eds.), *Second International Handbook of Science Education*. Dordrecht: Springer.
- Buldur, S. (2017). A longitudinal investigation of the preservice science teachers' beliefs about science teaching during a science teacher training programme. *International Journal of Science Education*, 39(1), 1–19.

- Bursal, M. (2010). Turkish preservice elementary teachers' self-efficacy beliefs regarding mathematics and science teaching. *International Journal of Science and Mathematics Education*, 8(4), 649–666.
- Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.
- Cakiroglu, J., Cakiroglu, E., & Boone, W. J. (2005). Pre-service teacher self-efficacy beliefs regarding science teaching: A comparison of pre-service teachers in Turkey and the USA. *Science Educator*, 14(1), 31–40.
- Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee, R. (Eds.), *Handbook of Educational Psychology* (pp. 709–725). New York, NY: Macmillan.
- Caleon, I. S., Tan, Y. S. M., & Cho, Y. H. (2018). Does teaching experience matter? The beliefs and practices of beginning and experienced physics teachers. *Research in Science Education*, 48(1), 117–149. Retrieved from <https://doi.org/10.1007/s11165-016-9562-6>
- Choi, S., & Ramsey, J. (2010). Constructing elementary teachers' beliefs, attitudes and practical knowledge through an inquiry-based elementary science course. *School Science and Mathematics*, 109(6), 313–324.
- De Jong, O. (2007). Trends in western science curricula and science education research: A bird's eye view. *Journal of Baltic Science Education*, 6(1), 15–22.
- Fenstermacher, G. D. (1979). A philosophical consideration of recent research on teacher effectiveness. *Review of research in education*, 6(1) 157–185.
- Fischer, H. (2001). Verfahren zur Erfassung von Lehrer-Vorstellungen zum Lehren und Lernen in den Naturwissenschaften [A method for detecting teacher ideas for teaching and learning in science]. *Zeitschrift der Didaktik der Naturwissenschaften*, 7, 105–120.
- Feucht, F. C. (2010). Epistemic climate in elementary classrooms. In L. D. Bendixen & F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice*. (pp. 55–93). New York, NY: Cambridge University Press. Retrieved from <https://doi.org/10.1017/CBO9780511691904.003>
- Greene, J. G., & Yu, S. B. (2016). Educating critical thinkers: The role of epistemic cognition. *Policy Insights from the Behavioral and Brain Sciences*, 3(1), 45–53. Retrieved from <https://doi.org/10.1177/2372732215622223>
- Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of inquiry-based learning on students' science literacy skills and confidence. *International Journal for the Scholarship of Teaching and Learning*, 3(2), Article 16.
- Hamilton, M. (2017). Pedagogical transitions among science teachers: how does context intersect with teacher beliefs? *Teachers and Teaching*, 24(2), 151–165. doi:10.1080/13540602.2017.1367658
- Jokic, B. (2016). Nacionalni kurikulum nastavnog predmeta kemije [National curriculum of the chemistry class]. Retrieved from <http://www.kurikulum.hr/wp-content/uploads/2016/03/Kemija.pdf>
- Kang, N.-H., & Keys, C. W. (2000). An investigation of secondary school science teachers' beliefs about and the practices of hands-on activities. Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans, LA.

- Koballa, T., Gräber, W., Coleman, D. C., & Kemo, A. C. (2000). Prospective gymnasium teachers' conceptions of chemistry learning and teaching. *International Journal of Science Education*, 22(2), 209–224.
- Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29(4), 331–359.
- Lunn Brownlee, J., Ferguson, L. E., & Ryan, M. (2017). Changing teachers' epistemic cognition: A new conceptual framework for epistemic reflexivity. *Educational Psychologist*, 52(4), 242–252.
- Markic, S. (2008). *Studies on freshman science student teachers' beliefs about science teaching and learning*. Aachen: Shaker.
- Markic, S., & Eilks, I. (2008). A case study on German first year chemistry student teachers' beliefs about chemistry teaching, and their comparison with student teachers from other science teaching domains. *Chemistry Education Research and Practice*, 9(1), 25–34.
- Markic, S., & Eilks, I. (2013). Prospective chemistry teachers' beliefs about teaching and learning – A cross-level study. *International Journal of Science and Mathematics Education*, 11(4), 979–998.
- Markic S., & Eilks I. (2014). Evaluating drawings to explore chemistry teachers' pedagogical attitudes. In Kahveci M., Orgill M. (Eds.), *Affective dimensions in chemistry education* (pp. 259–278). Berlin, Heidelberg: Springer.
- Markic, S., Mamlok-Naaman, R., Hugerat, M., Hofstein, A., Dkeidek, I., & Kortam, N. (2016). One country, two cultures - A multi-perspective view on Israeli chemistry teachers' beliefs about teaching and learning. *Teachers and Teaching: Theory and Practice*, 22(2), 131–147.
- Meijer, P. C., Verloop, N., & Beijaard, D. (2002). Multi-Method triangulation in a qualitative study in teachers' practical knowledge: an attempt to increase internal validity. *Quality & Quantity*, 36(2), 145–167.
- Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, 19(4), 317–328. Retrieved from <https://doi.org/10.1080/0022027870190403>
- O'Loughlin, M., & Campbell, M. B. (1988). Teachers' preparation, teacher empowerment, and reflective inquiry: A critical perspective. *Teacher Education Quarterly*, 15(4), 25–53.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332. Retrieved from <http://rer.sagepub.com/content/62/3/307>
- Richardson, V. (2003). Preservice teachers' beliefs. In J. Rath, & A. C. McAninch, (Eds.), *Advances in teacher education series*, 6 (pp. 1–22). Greenwich, CT: Information Age Publishing.
- Roth, K. J., Druker, S. L., Garnier, H. E., Lemmens, M., Chen, C., & Kawanaka, T. (2006). *Teaching science in five countries: Results from the TIMSS 1999 video study (NCES 2006-011)*. Washington, DC: U.S. Government Printing Office.
- Savasci-Acikalın, F. (2009). Teacher beliefs and practice in science education. *APFSLT*, 10(1), 1–14.
- Schommer-Aikins, M. (2004). Explaining the epistemological belief systems: introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39(1), 19–29.
- Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of*

Educational Psychology, 82(3), 498–504.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1–22.

Simicic, S. (2018). *Usage of particulate drawing in analysis, learning, testing and improvement of conceptual knowledge in the initial chemistry teaching*. Split: Faculty of Science.

Smith, L. (2005). The impact of early life history on teachers' beliefs: In-school and out-of-school experiences as learner and knowers of science. *Teachers and Teaching: Theory and Practice*, 11(1), 5–36.

Swanborn, P.G. (1996). A common base for quality control criteria in quantitative and qualitative research. *Quality and Quantity*, 30(1), 19–35.

Thomas, J., Pedersen, J. E., & Finson, K. (2001). Validating the Draw-A-Science-Teacher-Test Checklist (DASTT-C): Exploring mental models and teacher beliefs. *Journal of Science Teacher Education*, 12(4), 295–310.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: a synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics learning and teaching* (pp. 127–146). New York, NY: Macmillan.

Törner, G. (2002). Epistemologische Grundüberzeugungen – verborgene Variablen beim Lehren und Lernen der Mathematik [Basic Epistemological Beliefs – Hidden Variables in Teaching and Learning Mathematics]. *Der Mathematikunterricht*, 48(4/5), 103–128.

Uzuntiryaki, E., Boz, Y., Kirbulut, D., & Bektas, O. (2010). Do pre-service chemistry teachers reflect their beliefs about constructivism in their teaching practices? *Research in Science Education*, 40(3), 403–424. Retrieved from <https://doi.org/10.1007/s11165-009-9127-z>

Vladusic, R., Bucat, B., & Ozic, M. (2016a). Understanding ionic bonding – a scan across the Croatian education system. *Chemistry Education Research and Practice*, 17(4), 685–699. doi:10.1039/C6RP00040A

Vladusic, R., Bucat, B., & Ozic, M. (2016b). Understanding of words and symbols by chemistry university students in Croatia. *Chemistry Education Research and Practice*, 17(4), 474–488. doi:10.1039/C6RP00037A

Wilson, B., & Wilson, M. (1979). Children's story drawing: Reinventing words. *School Arts*, 8, 6–11.

Wehling, L. J., & Charters, W. W. Jr. (1969). Dimensions of teacher beliefs about teaching process. *American Educational Research Journal*, 6(1), 7–30.

Woolfolk-Hoy, A., Davis, H., & Pape, S. J. (2006). Teacher knowledge and beliefs. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (pp. 715–737). Mahwah, NJ: Lawrence Erlbaum.

Biographical note

LANA ŠOJAT, M.Sc. Chemistry Education, is a Chemistry teacher in secondary school in Zagreb, Croatia and a PhD student on Faculty of Science, University of Split. Her research interests include problem of pedagogical content knowledge in chemistry and beliefs of preservice and in-service chemistry teachers. Her interests include pre-school science pedagogy and working with gifted students.