



**Abstract.** *The (written) state curriculum is one of the cornerstones influencing education. Its specifically mediated by textbooks. In an open textbook market, the influence of the state curriculum is limited, and the main responsibility passes to individual schools or teachers. In order to understand education from the potential attainment of curriculum goals' point of view, it is necessary to pay attention to the teachers' textbook preferences. This research was focused on the field of lower-secondary chemistry education in Czechia, with special attention paid to the textbooks in use, their choice, and teachers' perception of them. The data were gathered using a questionnaire distributed to a representative sample of 387 lower-secondary school chemistry teachers. The results showed that teachers favor traditional chemistry teaching conceptions. Most teachers stated that textbooks play a vital role for them when preparing lessons and new textbooks are mostly chosen by the most experienced teachers. Most teachers also expressed their preference for textbooks which contain subject-matter ordered according to the structure of chemistry, i.e. not adjusted for learners, as well as textbooks dominantly orientated towards the transmissive approach to education. Regarding the teachers' perception of textbooks, potential limits were identified in implementing innovations in (chemical) education.*

**Keywords:** *chemistry textbooks, lower-secondary school science education, teachers' teaching conception*

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## PREFERRED CHEMISTRY CURRICULUM PERSPECTIVE: TEACHERS' PERCEPTION OF LOWER-SECONDARY SCHOOL TEXTBOOKS

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### Introduction

Based on the actions taken in many countries after the PISA and TIMSS results were published (e.g., Wiseman, 2013), it is possible to argue that curricula are the first to blame when educational outcomes do not meet expectations (see Elmas et al., 2020). However, there is a long distance between the state (written) curriculum and the attained curriculum, e.g., students' performance, which depends on teachers' – their translation of the intended curriculum into practice. For this purpose, teachers use textbooks to bypass the national curricular documents (Maňák & Klápko, 2006), and thus textbooks take on the role of the potentially realized curriculum (Chiappetta & Fillman, 2007). Most teachers admit changing curriculum at the state level would not affect their work with the current textbook (Sikorová, 2010). In an open textbook market, naturally, this reduces the state (or any institution for curriculum development) influence, at the expense of the growing influence of the so-called commercial curriculum (see Hemmi et al., 2013) issued by private subjects. While the state monitors the quality of the curriculum, the breadth of the used evaluation criteria allows for significant differences between textbooks (see Rusek & Vojíř, 2019). This can lead to significant differences between attained curriculum between students taught using different textbooks (cf. Wang & McDougall, 2019).

As desirable as it is to revise the curriculum, without comprehensive coverage of the reality in schools, curricular reform cannot have the intended effect (see Sikorová, 2010). A thorough examination of textbooks is needed, from their content, through the concept and the manner and purpose of their use in education. Following others (Vojíř & Rusek, 2019b), this study explores the field of lower-secondary chemistry textbooks use in Czechia, where textbooks represent various curriculum alternatives teachers use, how important they consider textbooks, as well as the way they choose a concrete book set. Despite being conducted in Czechia, due to similarities with science/chemistry textbooks in other regions (see the chapter below), the findings in this research have more general validity.



## Theoretical Framework

To understand the impact of textbooks on education, the following aspects emerge from the literature: textbooks as school curriculum, the textbook's importance, the method and purpose of using textbooks, the teachers' satisfaction with the textbook and the textbook selection. This field remains almost unmapped in science education (Vojří & Rusek, 2019b). As textbooks play an important role in the preparation and structuring of instruction (Loewenberg-Ball & Cohen, 1996), it is not possible to realize broader changes in education unless reform ideas are integrated into the (new) textbooks in use (Mikk, 2000). For this reason, the study of the above-mentioned aspects is an important part of the theory of curriculum implementation, as this research points to the possible limits that need to be addressed.

### *Textbooks as School Curriculum*

The conclusions of several studies suggest that textbooks serve teachers across school subjects as the primary source for instruction (see e.g., Mullis et al., 2012), the main information source of the lesson content (Chou, 2020; Johansson, 2006) or a source of supporting graphics (Shehab & BouJaoude, 2017). A teacher's length of practice affects the extent to which they use textbooks (Horsley, 2009; Loewenberg-Ball & Cohen, 1996). Textbooks are reported to strongly influence teachers' decisions about selecting subject-matter, as well as teaching methods (Lepik et al., 2015). Therefore, it seems that state curricula are mediated by textbooks, or may even be bypassed when textbooks differ from them. Sikorová (2010) reported on the results of interviews following lesson observations. In her study, 67% of teachers admitted using only one textbook when designing the part of the school curriculum for the subject they are responsible for (41% of the research participants followed the textbook precisely). Bakken (2019) reported that teachers tend to consider textbooks to be the obligatory plan. Sikorová (2010) found that 26% of the teachers followed the book systematically when preparing their lessons, with only 55% modifying the content anyhow and only 19% using several different sources of information. In other cases, textbooks were found to provide additional materials for teachers: a more detailed description of the course, additional didactical suggestions, and theoretical background knowledge (Steenbrugge et al., 2013). The textbooks which offer lesser teacher support and refer to several topics within one unit were considered worse (Steenbrugge et al., 2013).

It is therefore obvious how significant textbooks are in teachers' curriculum interpretation. To be put into practice, the state curriculum needs to be discussed in more depth with teachers. Solely revising the curriculum at the state level will not affect school practice unless the textbooks are revised accordingly.

### *The Method and the Purpose of Using Textbooks in Education*

An important factor in this area is the period for which textbooks are used in lessons. Červenková (2010) found that textbooks were used in 76% of the observed lessons in different school subjects. These were used in 31% of the lesson time (i.e., about for about 14 minutes per lesson). Almost 45% of all teachers in the study (Finland, Norway, Estonia) reported using the textbook only as an exercise book. Students seem not to be given the opportunity to learn (mathematics) from the textbook without the teacher's mediation (Lepik et al., 2015). In this respect, Sikorová (2010) reported that textbooks were used for new subject-matter processing in 44% of mathematics lesson time-lengths, 40, resp. 38% for fixing subject-matter, practice resp. recap. The teachers were reported to be modifying the tasks from the textbooks, reducing their cognitive demand and, thus, reducing their potential (Son & Kim, 2015).

Teachers' tendency to control the process of students' work with the textbook may be due to their distrust of the textbook or the reason behind a curricular objective. The used textbook affects the time teachers have their students work individually with the textbook (Neuman et al., 2015). This could be further explained by Červenková (2010), who found that textbooks are very rarely used for homework. Also, the extent to which teachers use textbooks does not depend on the level of education (Červenková, 2010; Sikorová, 2010).

With the above-mentioned findings in mind, it seems that teachers mostly prepare their lesson according to the textbook (cf. Stein et al., 2007). According to Bergqvist and Chang Rundgren (2017) the textbook content, subject-matter and methods used in observed lessons correlate. This also applies to the models and examples or analogies used (Harrison, 2001).



Considering the existence of teachers' books, the textbook, nevertheless, seems to be oriented towards students. However, for this purpose, the textbooks are used only seldom (Tulip & Cook, 1993). This may be explained by findings among Finnish teachers. They attempt to cover the whole textbook in a limited time frame, which causes a feeling of urgency and pressure during lessons (Perkkilä, 2002). Similar results were reported in Norway (Hundeland, 2011). It is possible to infer that teachers tend to follow the content to fulfill this demand, without considering the attained curriculum.

#### *Teachers' Perceived Importance and Satisfaction with Textbooks*

As mentioned above, the importance of textbooks resides in its perceived role of concretized curriculum. There is only limited research providing information in this area. Textbooks are seen as important because teachers consider them support in their work (cf. Bakken, 2019). Significant differences were found in the backing the teachers feel when using particular textbooks (Neuman et al., 2014). Teachers in Norway consider textbooks medium-important when choosing teaching strategies (Lepik et al., 2015), 73% of their Czech colleagues consider textbooks necessary (Červenková, 2010).

As far as satisfaction with textbooks is concerned, the above-mentioned relationship to teachers' teaching style plays an important role. Different levels of satisfaction with the textbooks seem to be mirrored in their use (Son & Kim, 2015). In their research, they showed clear patterns in teachers' views of mathematics textbook.

#### *Textbook Selection*

There are several countries where textbook selection is the teachers' responsibility. For example, in Finland and Estonia, teachers often choose the textbooks themselves (Lepik et al., 2015). Similarly, in Brazil, the most experienced teacher usually chooses the books without much dialogue with colleagues, coordinators, or the school director (Bizzo et al., 2007). At most two or three teachers exchange information and analyze the books together. For this purpose, several authors suggested evaluation rubrics for teachers to use as an aid in textbook selection (see Bölsterli, 2015; Sikorová, 2007).

Teachers look for a book that is adaptable to their teaching style rather than for a book to which they would have to adapt the classes (Bizzo et al., 2007). This makes diffusing innovation via textbooks more difficult. Bizzo et al. (2007) also found that the most significant criterium for choosing textbooks is the quality of images. In this case, teachers then use the same models as shown in the textbooks (Harrison, 2001). There is a clear preference for books with simple and easy-to-do experiments (using common and non-expensive materials) (Bizzo et al., 2007). This, again, refers to the teachers' interpretation of a textbook's purpose - for teachers rather than for students.

#### *The Czech Perspective*

In Czechia, primary and lower-secondary schools receive special funding to provide their students with textbooks which have received a so-called *approval clause* (a certificate by the Ministry of Education confirming that the books are suitable for use in education according to the curriculum, use appropriate methods etc.). The clause is provided to a book based on its publisher's demand for six years. After this period, the publisher can ask for its renewal. De jure, schools are also allowed to use textbooks without the approval clause. This opens the market to private companies who technically employ teachers or academics as textbook authors.

As far as lower-secondary chemistry textbooks are concerned, there were five textbook series by four publishers on the market which were granted the approval clause at the beginning of this research. After opening the textbook market in 1989 (Vojíš & Rusek, 2020), several other textbooks series were published. They can still be used by teachers in individual cases. For full bibliographic information about the textbooks referenced in the text, see Table 1. As far as the overall elaboration of these textbooks, it is important to mention their didactical equipment varies only slightly and shows authors' similar conception of textbook elaboration (Rusek et al., 2020).



**Table 1***The List of Referenced Textbooks*

Textbook title	Published*	Authors	Publisher	Reference in the text
Základy chemie 1; 2 [Basics of chemistry]	1993	Beneš, P., Pumpr, V., Banýr, J.	Prague: Fortuna	ZCH
Nebojte se CHEMIE [Do not be afraid of chemistry]; Chemie se nebojíme [We are not afraid of chemistry]	1994; 1996	Los, P., Hejsková, J., Klečková, M.	Prague: Scientia	SC
Chemie pro8. ročník; Chemie pro9. Ročník [Chemistry for 8th and 9th grade]	1998	Čtrnáctová, H., Zemánek, F., Svobodová, M., Dušek, B.; Novotný, P., Sejbál, J., Zemánek, F., Svobodová, M.	Prague: SPN	SPN
Základy praktické chemie 1; 2 [Basics of practical chemistry]	1999, 2000	Beneš, P., Pumpr, V., Banýr, J.	Prague: Fortuna	PCH
CHEMIE Krok za krokem [Chemistry step by step]; CHEMIE Na každém kroku [Chemistry on every step]	1999, 2000	Bílek, M., Rychtera, J.	Pardubice: Moby Dick	MD
Chemie I; II	2004, 2007	Karger, I., Pečová, D., Peč, P.	Olomouc: Prodos	PR
Chemie 8; 9	2006, 2007	Škoda, J., Doulík, P.	Plzeň: Fraus	FR
Chemie 8; 9	2010, 2011	Mach J., Plucková I., Šibor J.	Brno: Nová škola	NS
Chemie 8; 9	2018	Škoda, J., Doulík, P., Šmídl, M., Pelikánová, I.	Plzeň: Fraus	nFR

\*Years of first publishing; the two records relate to the two books for 8th and 9th grade.

Results from other disciplines (see Červenková, 2010; Sikorová, 2010) suggest that the perception of textbooks does not vary among teachers from different fields (school subjects).

At the moment, the lower-secondary school chemistry textbooks provided with the approval clause can be divided into the following categories:

1. Textbook series written, and first published hand in hand with the introduction of the previous curriculum: ZCH
2. Textbook series published before the introduction of the current curriculum: PCH, PR
3. Textbooks published after the introduction of the contemporary curriculum: FR, NS, nFR (new edition of FR)

The textbooks SC, SPN and MD would belong to the second category, however, their approval clause has expired. Yet, they are still available on the market.

The *primarily* published textbooks, ZCH, follow the traditional paradigm (cf. Johnstone, 2010): They begin from an abstract level of general chemistry, followed by inorganic, organic chemistry, and biochemistry. The content is concluded with the use of chemistry in society. Within the chapters (themes), the content is presented in the following structure: introduction to the topic, explanatory text, experiment(s), pictures, tasks and conclusion, resp. extending text.

The textbooks from the *second* category were created as alternative (competitive) projects, nevertheless, they follow the same education paradigm being organized in a similar way to the textbook set in the first category as far as the subject-matter order, extent and the method of presentation are concerned. This shows that the educational goals as well as subject matter did not undergo significant changes with the reformed curriculum. Also, with respect to the date of these textbooks' being published, they contain rather outmoded graphics, photos of common objects contemporary students no longer recognize as well as outdated information.

The textbooks from the *third* category represent modern textbooks as far as the formatting and graphics are concerned. They also use direct links to the current curriculum (key competences, cross-cutting topics, expected outcomes, etc.). These textbooks, however, fundamentally differ among each other both in the subject-matter structure and the way it is presented. In the FR textbook set (Škoda & Doulík, 2006, 2007) the authors, as the only ones so far, attempted to change the typical subject-matter presentation frame, positioning carbohydrates



among hydrides, i.e., to the first book. (In the rest of the textbooks, this topic is presented in the second book for the 9<sup>th</sup> grade.) This step completely changed the approach as it broke the traditional division into general, inorganic, organic chemistry and biochemistry presented (and taught) in this order (Vojří & Rusek, 2020). This change, however, was mostly misunderstood and unadopted by teachers. For this reason, the authors reworked the original textbooks placing the subject-matter in the usual order. However, the newest, renewed edition of the nFR textbooks were not present in schools at the time this research was conducted. Nevertheless, this textbook series varies the most in its presentation of the subject-matter. Its structural elements are closely linked, and the explanatory text therefore blends with the tasks, resp. experiments into one complex. Links to other sources of information, interdisciplinary and other references are also typical.

On the contrary, the NS textbooks represent a more traditionally conceived textbook. Their authors used the traditional subject-matter order and presentation similar to the ZCH textbooks. There are links to the state curriculum and selected vocabulary terms in foreign languages. As far as text difficulty is concerned, PCH was proved the easiest to read, containing the same number of scientific terms, whereas NS was found the most difficult to read (Rusek et al., 2016).

In the majority of countries, the so-called commercial curriculum (Hemmi et al., 2013) plays an important role when several textbooks are available (see e.g., Phillips, 2014; Vojří & Rusek, 2020). This supports the role of the teacher as a creative professional who manages the educational process when they choose the teaching materials themselves. If textbook selection is left to schools or individual teachers, they choose, and are satisfied with, a textbook representing a curriculum which corresponds to their teaching conception. Therefore, the way to understand educational reality from the perspective of a potentially realized curriculum is to investigate which textbooks are used during education as well as for its preparation and how teachers perceive them. Textbooks are concrete forms of intended curricula, catering for a certain conception. By deciding to use them, teachers show their preference about this conception of education. Since teachers are the "end-point" implementors of any curricular changes, their attitude towards curriculum, especially to the educational conception translated in textbooks, reflects the potentials and limitations of diffusing innovation in education. As suggested by the above-mentioned examples from Czechia, Estonia, Finland or USA, this process is valid in an international context.

### *Research Aims and Questions*

The aim of this research was to map the field of lower-secondary chemistry education in Czechia, with special attention to the textbooks in use and teachers' perception of them. As different textbooks contain a different way of transforming subject-matter, teachers' preferences as well as their satisfaction with a textbook show their inclination to a certain representation of chemistry curriculum. It is then reflected in teachers' textbook selection, which can, however, be influenced by both the textbooks available and the textbook selection process at particular schools. This shows the potential influence of textbooks (the concrete representation of curriculum) on educational content and method selection in teaching practice. Based on this, the following research questions were formulated:

1. Which chemistry textbooks are provided to lower-secondary school students and which textbooks are used by teachers to prepare for teaching?
2. To what extent are teachers satisfied with the textbook they provide to their students?
3. How important are textbooks for teachers' lesson preparation?
4. How were the chemistry textbooks being selected in schools?
5. Having the chance, which textbook would chemistry teachers want to provide their students?

Teachers' perceived textbook importance, satisfaction with a textbook(s) they use, the way textbooks were selected at their school as well as textbooks they would like to use in their lessons are interconnected and therefore affect each other. Also, teachers' length of practice and/or their field of study (chemistry education, other field education, or chemistry-oriented program complemented with additional teacher training) was reported to influence their teaching practice (e.g., Červenková, 2010; Rusek et al., 2017). These characteristics could therefore have an effect on teachers' approach to a curriculum representation in concrete textbooks. For this reason, hypotheses based on the following framework relations were tested to answer the research questions:

1. The effect of teachers' practice length OR the field of their study vs the textbook they use.



2. The effect of the length of teachers' teaching practice OR their field study OR the textbook they use on their satisfaction with the textbook.
3. Teachers' perceived importance of a textbook for lesson preparation is affected by the length of their practice OR their field of study OR their satisfaction with the textbook OR on the textbook they use.
4. The way textbooks were selected affects which textbook they use OR their satisfaction with the textbook.
5. The length of teachers' practice affects the way textbooks were selected at their school.
6. The length of teachers' practice OR the field of their study affects which textbook they would like to use.

## Research Methodology

### *General Background*

In this research, a primary quantitative method, namely questionnaire survey was employed. A representative sample of lower-secondary school chemistry teachers in Czechia provided information about their use of chemistry textbooks with a special attention to the textbook selection. A validated online questionnaire was used for this purpose. The research was in progress during September and November 2018.

### *Research Tool*

An online questionnaire was designed to obtain information about: demographic information - length of professional practice, field of education, number of colleagues - chemistry teachers; chemistry textbook in use; satisfaction with the textbook; textbooks used for the lesson preparation; perceived importance of the textbook for the lesson preparation; the way of choosing a textbook at their school; and wanted textbook to provide the students now. Its items were subject to content validation. A specialist panel ( $N = 8$ ) consisted of Chemistry teacher trainers and researchers and authors of seven series of chemistry textbooks for lower-secondary schools. The questionnaire was modified in cooperation with an expert panel and subsequently piloted in order to check for internal consistency as well as prospective phrasing vagueness (Vojtř & Rusek, 2019a).

The questions in the questionnaire were mainly closed-ended. In the case of the used textbook, a textbox was added for other options. A 5-point Likert scale was used to assess the teachers' satisfaction with textbooks (1-completely satisfied to 5-completely dissatisfied) and perceived importance of a textbook for lesson preparation (1-very important to 5-completely useless). The questionnaire pilot (Vojtř & Rusek, 2019a) showed that the questions are understandable. Also, several options were added to the questionnaire according to the responses (other textbooks, textbook selection etc.). For a deeper understanding and interpretation of teachers' attitudes, a textbox for free expression on the issue of chemistry textbooks was also included. The respondents' statements in italics are used later in the text to support some conclusions.

### *Sample Selection*

To select participants for the study, the Czech Ministry of Education's statistical yearbook (2018a) was used. Based on the total number of lower-secondary schools in Czechia (2729), a minimal sample of 337 schools was determined on a 95% confidence level using the minimal-sample calculator Raosoft (<http://www.raosoft.com/sampleize.html>). As the yearbook does not contain information about the school-type, i.e., whether a school offers all nine grades and chemistry is being taught, a special ratio needed to be calculated. The minimum sample was multiplied by the proportion of lower-secondary schools in the whole basic school sample (4155), i.e., the coefficient was 1.52. Moreover, with the expected 33% online surveys' response-rate (cf. Nulty, 2008), the number of schools in the sample was tripled. A list of schools from the Ministry's school address-book (2018b) was used, the schools in it assigned random numbers using the random-number generator in MS Excel and ranked with the first 1536 schools addressed with the questionnaire.

A motivation letter with an explanation of the study was sent together with instructions and a link to an online questionnaire. School management forwarded the link to their Chemistry teacher(s). After the first email, only 192 teachers (from 189 schools) filled in the questionnaire. For this reason, the request to fill the questionnaire in was sent to the rest of the schools again. By doing so, a total number of 387 teachers from 370 schools responded.



To calculate the response-rate, the list of addressed schools was evaluated to identify only "full basic schools". Based on this process, 502 schools where chemistry is not being taught were excluded from the sample. Also, for the same reason, special and practical schools for handicapped students (108) or schools offering only temporary schooling, e.g., schools by hospitals (23) were excluded too. The research sample was then 903 addressed schools. The 41% response-rate is considered satisfactory (see Nulty, 2008). As the sample exceeds the minimum sample, the data can be generalized for all lower-secondary schools in Czechia and, with respect to the number of teachers in the sample, also to the lower-secondary teacher population in Czechia. The results therefore offer a complex overview of chemistry textbook use at lower-secondary schools in Czechia.

#### *Research Participants' Demographic Information*

Taking the number of respondents and random selection into account, the respondents' characteristics can be generalized to all chemistry teachers in lower-secondary schools in Czechia. The results suggest that chemistry in lower-secondary schools is mostly taught by women (86%). The length of the majority of the teachers' practice (74%) exceeds 10 years. Only a small proportion of novice teachers is represented, see Table 2.

The teachers (98%) mostly teach chemistry only at lower-secondary schools. In most schools (69%), there is only one chemistry teacher. Two chemistry teachers teach at 22% of schools. Most teachers (65%) graduated from university with a degree focused on chemistry education. A significant proportion of the teachers (12%) studied pure chemistry or an educational field of non-chemical focus (13%). 9% of the teachers graduated from a completely different field. Only 2% of the interviewed teach solely chemistry. In addition to chemistry, most teachers teach one or two other school subjects (both 34%). However, a significant share of teachers (30%) also teach four or more school subjects. The most frequently represented combinations of chemistry with other educational disciplines include biology ( $N = 217$ ), mathematics ( $N = 126$ ), physics ( $N = 98$ ), "Man and the world of work" ( $N = 72$ ), ICT ( $N = 68$ ), health education ( $N = 53$ ) and geography ( $N = 51$ ).

**Table 2**  
*The Lower-Secondary Chemistry Teachers' Practice Length*

Length of practice	Number of teachers	Proportion of teachers (%)
< 1 year	13	3
2-3 years	27	7
4-5 years	28	7
6-10 years	34	9
> 10 years	285	74

#### *Data Analysis*

In order to answer research questions about the textbooks in use, teachers' preferences, textbook selection, etc. simple descriptive methods were used in MS Excel. As far as the rest is concerned, IBM SPSS Statistics 26 software was used. The research tool consisted of nominal and ordinal variables only. The variables: satisfaction with the textbook, perceived textbook importance for lesson preparation and the length of a teacher's practice are considered ordinal. The variables: field of teacher's study, textbook in use, textbook choice, and textbook a teacher would like to acquire are nominal.



Goodman and Kruskal's gamma (Goodman & Kruskal, 1954) was used as the rank correlation measure between the ordinal variables. To interpret the effect size, the values according to (Rea & Parker, 1992) were used. The Kruskal-Wallis test (Kruskal & Wallis, 1952) was used to test the null hypotheses formulated for all the hypotheses concerning the ordinal variables together with the nominal variables. In order to examine these values' effect size,  $\epsilon^2$  (Tomczak & Tomczak, 2014) was used. This index was used because it seems to be less biased than other commonly used effect size indices (Okada, 2013). Also, it is equivalent to the adjusted  $r^2$  (Allen, 2017) so the squared bounds of R interpretation by Rea and Parker (1992) were used.

The hypothesis containing only nominal variables was tested using Pearson's chi-squared test. For the purpose of effect-size evaluation, Cramer's  $V$  (Cramér, 1946) was used and interpreted according to Cohen (1988).

## Research Results

### *Chemistry Textbooks in Use*

Schools mostly provide their students with chemistry textbooks by NS (38%), ZCH (28%), FR (20%), PCH (16%) and PR (5%). Other textbooks appear in schools only seldom. In only three cases (.8%), teachers mentioned they do not provide their students any textbooks. Also, 11% of schools provide the students with more than one chemistry textbook. Thus, individual textbooks do not seem to fulfil the teachers' ideas in all aspects, so they choose individual components across different books. This is confirmed by some of the teachers' comments in the questionnaire: *"I'd like a combination of individual textbooks." "I'd like to combine textbooks."*

Despite different novice (early-career) and experienced teachers' needs were expected, the Kruskal-Wallis test results for groups of teachers according to the textbooks in use showed no statistically significant difference in the length of their teaching practice ( $p = .183$ ). However, a statistically significant relation was found between the studied field and the used textbook ( $p = .019$ ). Cramers'  $V$  indicated a medium association ( $V = .172$ ). While teachers who studied pure chemistry, chemistry or another field's teaching most often use the NS textbooks, teachers who graduated from another field (not focused on chemistry or teaching) most often use FR (26.5%) and ZCH (20.6%) textbooks. However, the smallest proportion of these teachers participated in the selection of the textbook. Only 26.5% of them chose the textbook on their own (see below). The use of newly published textbooks with traditional conception thus prevails among teachers, regardless of their university studies' field or length of practice.

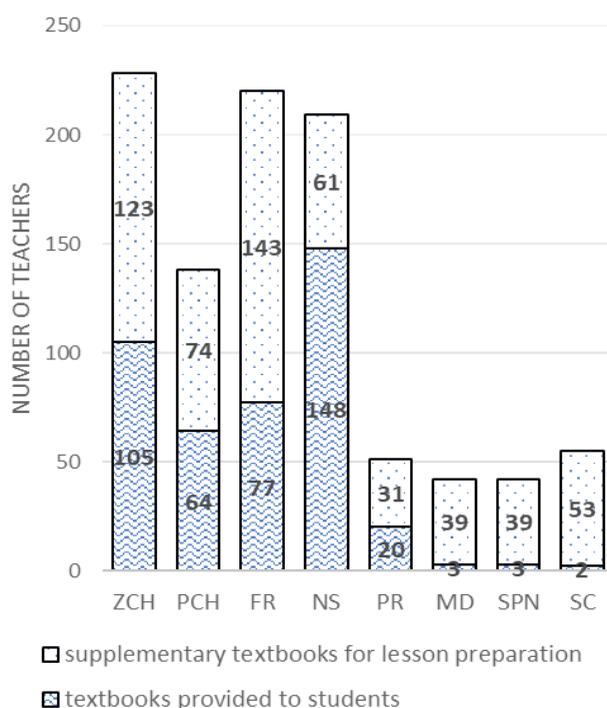
Most teachers (83%) answered they also used other textbooks than those provided to their students when they prepared for teaching. Even among these textbooks, the most common are ZCH, PCH, FR and NS, see Figure 1. This strengthens the potential impact of these textbooks on education.

The available textbooks were proven to affect teachers who do not directly work with the textbook in their classes and use other teaching materials. *"The textbook is a marginal material for me because I prepare worksheets myself, into which I draw suggestions from various textbooks, seminars and other materials. The worksheets correspond with our school curriculum."* A significant number of teachers also mentioned using the textbooks provided to students only seldom. This is the case for MD, SPN or SC textbooks (see Figure 1). 6% of respondents mentioned they also use other textbooks. 2% of the respondents use higher education chemistry textbooks to prepare for teaching. With respect to the adequacy of teaching, this approach is questionable mainly because of the oversaturating educational content and students' inadequate mental development.

The teachers were mostly (67%) rather satisfied with the textbooks they used with students ( $Mdn = 2$ ). A statistically significant difference was found between the groups of individual textbook users in their satisfaction with the textbook rating ( $p < .001$ ). The effect of this difference is *relatively strong* ( $\epsilon^2 = .237$ ). Teachers who use NS textbooks are more satisfied with them ( $Mdn = 1$ ) than teachers using all the other textbooks (PCH, ZCH:  $Mdn = 2$ ; FR, PR:  $Mdn = 3$ ). None of the teachers who use the NS textbooks expressed *dissatisfaction* or *complete dissatisfaction* with the books. It turned out teachers prefer a newly released textbook, which, however, keeps the traditional structure of the subject-matter and its mediation.



**Figure 1**  
Numbers of Teachers Using Particular Textbooks to Prepare for Teaching



#### Teachers' Satisfaction with the Textbooks in Use

The FR textbooks were criticized mostly for the order of the subject-matter. "For example, organic chemistry is not placed in one block but is partly placed in the 8<sup>th</sup> grade followed by a part of inorganic chemistry and the rest of organic chemistry is placed in the 9<sup>th</sup> grade." As far as ZCH and PCH textbooks are concerned, the teachers criticized some information as well as their graphical appearance being obsolete. "I'm satisfied with the subject-matter, graphical set-up is little old-fashioned and current information is missing."

A moderate-strong correlation of teacher's textbook satisfaction and their length of practice was found ( $p < .001$ ;  $\gamma = -.308$ ). Teachers with a more than 10 years length of practice are significantly more satisfied with the used textbooks ( $Mdn = 2$ ) than novice teachers with 1-3 or 5-10-years practice length ( $Mdn = 3$ , respectively 2.5). This finding could be explained by the concept of teaching presented in the textbooks. It seems there is a gap between textbooks and the implementation of teaching concepts that freshmen teachers gain from their university study.

A statistically significant difference was found in satisfaction with the textbook in use ( $p = .027$ ) among teachers' groups according to their field of study. The effect size of the difference is, however, weak ( $\epsilon^2 = .028$ ). 70% of the teachers who studied chemistry education showed satisfaction with the textbooks they used. So did 64% of the teachers who studied other education fields than chemistry and only 55% of the teachers who studied chemistry. In comparison, teachers with a degree in chemistry are statistically significantly less satisfied with the textbook ( $Mdn = 3$ ) than teachers who studied chemistry education ( $Mdn = 2$ ). This result shows different expectations from chemistry textbooks' conception and role among these teacher groups. Qualitative statements suggest that teachers who studied chemistry put more emphasis on the content compared to its didactic transformation. "Textbooks need to be supplemented with serious sources of information, they are not suitable for preparing students to study at grammar schools and technical schools. Although they are playful and pleasing, they do not provide enough information and are not structured logically."

### *Importance of Textbooks for Lesson Preparation*

Although textbooks are a tool intended for students, many teachers also use it to prepare for teaching. 49% of the teachers consider textbooks *important* for lesson preparation, with only 10% considering the textbook *unimportant* for lesson preparation and 1% *completely unimportant* ( $Mdn = 3$ ). This confirms the role of textbooks as the next article of the curriculum.

Despite the assumption of novice teachers' higher need for available materials for their lesson preparation, a significant correlation between a textbook's perceived importance for lesson preparation and the length of the teachers' practice was not found ( $p = .193$ ). Also, no statistically significant difference ( $p = .156$ ) was found in the textbook's perceived importance for lesson preparation between the groups of teachers according to their field of study.

Compared to that, a significant correlation ( $p < .001$ ) was found in terms of teachers' satisfaction with the textbook in use and its perceived importance for lesson preparation. The effect of the correlation ( $\gamma = .244$ ) is moderate. 76% of teachers who consider the textbook to be important for lesson preparation are satisfied with the textbook in use (8% dissatisfied). On the contrary, 49% of the teachers who do not consider textbooks to be important for lesson preparation are satisfied with the textbook in use (dissatisfied 18%). Given the prevailing number of teachers who consider the textbook to be important for their lesson preparation, it turns out that for most teachers the currently used textbooks fulfil their idea of the educational tool.

In line with these findings, a statistically significant difference ( $p = .027$ ) was found in the textbook's perceived importance for lesson preparation among the groups of teachers according to the textbook they used. The effect size of this difference is medium ( $\epsilon^2 = .041$ ). Compared to other more frequently used textbooks, the NS textbooks are exceptional. The teachers rate it as more important for lesson preparation ( $Mdn = 2$  vs.  $Mdn = 3$ ). This textbook seems to fulfil the majority of teachers' needs as a textbook for use in lessons as well as a teachers' book, due to its conception.

### *The Method of Textbook Selection*

Most teachers (42%) answered they chose the textbooks themselves. This means the teachers could choose a textbook that best suits them for their work and teaching conception. On the contrary, 39% of the teachers did not have any influence on textbook choice. It was either already available at their school (34%) or chosen by the school management without consulting a teacher (school management 4%, the head of the subject-committee 1%). A statistically significant association of the medium effect was found between the way the textbook was selected and the textbook in use ( $p < .001$ ,  $V = .213$ ). Most teachers (59%) who chose the textbook set on their own chose the NS textbooks. In contrast, for the first published textbook, ZCH, the reason for their use is their presence in schools (57%). For the FR and PCH textbooks, the shares of a separate selection of textbooks and their use by the teacher due to their availability in school are comparable (37 and 40%). This technically means that the traditional, chemistry teaching paradigm represented by a textbook is being followed even after a textbook is replaced with a newer one.

A statistically significant difference in textbook choice was found among the groups of teachers according to the length of their practice ( $p < .001$ ). Effect size of this difference was medium ( $\epsilon^2 = .105$ ). Only out of the teachers with more than 10 years' practice was the majority involved in textbook selection (48.4% chose the textbook and 22.1% chose the textbook in agreement with other teachers). For groups of teachers with up to 10 years' practice, the use of textbooks prevails due to their availability at their school. This seems to be an important factor in the implementation of innovative curricula in schools.

The possibility to choose a textbook proved to be important also by the finding of a statistically significant difference in teacher satisfaction with the textbook among the teachers' groups according to the textbook selection process ( $p < .001$ ). The effect size of this difference was relatively strong ( $\epsilon^2 = .220$ ). Teachers are more likely to feel comfortable with the textbook in use if they chose it themselves ( $Mdn = 2$ ) compared to the option when they use textbooks that were already available in school ( $Mdn = 3$ ), or the textbooks chosen by the school's management ( $Mdn = 3$ ). The same also applies for teachers who chose the textbooks together with their colleagues ( $Mdn = 2$ ). Whereas in cases when teachers took part in textbook selection, 83% are satisfied with the textbook (2% dissatisfied), only 41% of teachers who did not choose the textbooks themselves are satisfied with the textbook they use (25% dissatisfied).



*Textbooks Teachers Would Like to Acquire in Case of Present Choice*

Only 57% of teachers answered they would not want to provide their students with another chemistry textbook, as they considered the current textbook in use to be sufficient or did not want one of the others currently available. 23% of teachers mentioned they did not know which textbook they would like to provide to their students instead of the current one. These teachers seem to lack an overview of the currently available textbooks. Among textbooks that the teacher would like to provide to their students, the latest NS and FR textbooks dominate. This could either be explained by the respondents' successful choice or the fact they are less informed about other textbooks' content. On the contrary, 34% of teachers who did not participate in selecting the textbooks do not want to provide their students with another textbook.

A statistically significant difference was found in the length of the teachers' practice among the groups of teachers divided according to the textbook they would like to acquire ( $p = .002$ ). The effect size of this difference is medium ( $\epsilon^2 = .068$ ). Most novice teachers (54%) do not know which textbook they would like to use.

Most teachers with longer practice stated that the textbook they currently use suits them best or do not want another of the currently available textbooks. The proportion of teachers who do not want another textbook is the highest in the group of teachers with more than 10 years of practice (64%). However, even for them, the second most common answer is that they do not know what textbook they would like to use with their students (19%). These teachers do not seem to have enough information in this respect or do not consider this important.

A statistically significant association of the medium effect was found between the teachers' field of study and the textbook that they would like to acquire ( $p = .026$ ,  $V = .187$ ). Teachers who studied pure chemistry or chemistry education do not usually want to acquire a different one of the currently available textbooks (57 resp. 61%). 19 or 20% do not know which textbook to provide their students with. In contrast, for teachers who studied a program focused on another field of education than chemistry, these groups are balanced (43% do not want to acquire textbooks other than the one they currently use, 40% do not know which textbook they would like). Out of these teachers, a higher proportion does not have an overview of the available textbooks.

**Discussion**

As far as the sample is concerned, there are several aspects worth mentioning. The results of the study showed that chemistry in lower-secondary schools is typically taught by women with more than 10 years of practice. There is a significant gender imbalance and compared to the ratio of women and men in lower secondary education in Czechia - the ratio of women is even higher (86 vs. 75% of women) (MŠMT, 2018a). Although most teachers graduated in chemistry education programs, 35 % studied other fields. This increases the demands on the materials available to these teachers. The importance of the materials grows when these teachers are the only ones teaching chemistry at their school and thus are responsible for the didactic transformation of the content as well as for creating the school's chemistry curriculum. Despite Czech teachers mostly study programs combining two fields, a significant share (30%) teach four or more school subjects. This can be seen as an undesirable feature, as in a larger number of subjects taught, a teacher's attention may be fragmented due to the increased demands of preparing content for different classes. This problem relates to supplementing the teachers' workload at smaller schools with the lower number of classes in a grade as well as the problem to gain fully qualified teachers for all fields. These responses of the school systems to teacher shortages are common in many countries (OECD, 2005). In perspective of possible curricular innovations this aspect emphasizes the need for well-prepared materials accompanied with thorough instructions how to use them (cf. Chen et al., 2019).

The results of this study showed that teachers prefer a newly published textbook, that maintains the traditional structure of the subject-matter and its mediation. This corresponds to Bergqvist and Chang Rundgren's results (2017) on Swedish chemistry textbooks. In the same sense, the only textbook set that differs in the structure of the subject-matter was proven unsuccessful. This voice contradicts Johnstone's (2010) critique of a rather old-fashioned approach towards chemistry subject-matter presentation. Despite being rather satisfied with textbooks in use, teachers seem to have different expectations from chemistry textbooks' conception and role. They vary according to their field of study. Almost half of the teachers who studied pure chemistry are



not satisfied with the textbooks. There is no research to support this interpretation, but this could be caused by their focus on the content, whereas textbooks bring its didactical transformations. These teachers, along with the 30% of teachers who studied chemistry education or 36% who studied another educational field are unlikely to use textbooks in their practice. Supporting these teachers, but also directing their performance is then made more difficult. These teachers are expected to rely on resources from the internet or their own preparation which, in principle, diminishes state control over the implemented curriculum and even worse inhibits any top-down attempts for reform.

Textbooks were confirmed as an important tool for a significant group of teachers to prepare for their teaching. A similar phenomenon was also observed for example in Scandinavia (Lepik et al., 2015). This proves that textbooks represent curriculum for many teachers. However, the way a textbook, as a material for students, is elaborated, is expected to differ from a material for teachers. This is supported by the findings concerning the textbook text difficulty (Rusek et al., 2016; Rusek & Vojříř, 2019), which teachers seem not to take into account when assessing the textbook's eligibility. No differences were found in the use of the textbook for the preparation of teaching according to the teachers' length of practice or the field of study. This result is surprising as according to Loewenberg-Ball and Cohen (1996), the teachers with shorter teaching practice showed they used textbooks for their lesson preparation more. Also, more experienced teachers were expected to have formed their own lesson preparations. This research, however, suggests otherwise. The perception of the textbook is thus mainly related to the overall concept of teaching (Bergqvist & Chang Rundgren, 2017), which is shown to be relatively uniform among teachers. It was also found that teachers who considered the textbook important for the preparation of teaching were rather satisfied with the textbook in use. Currently used textbooks are likely to be consistent with their teaching concept (cf. Li, 2013; Orafi & Borg, 2009). With the most frequently used textbook series in mind, it is possible to conclude that the potentially implemented curriculum follows the traditional paradigm of chemistry teaching in most schools. This is a clear indicator of the need for reconsideration (cf. Johnstone, 2010) as by relying on the traditional chemistry teaching paradigm school chemistry turns into a mere "teaching about the former condition of chemistry" which naturally widens the gap between the school subject and scientific discipline.

The second most commonly used textbook is a book which survived three reforms of the state curriculum (Vojříř & Rusek, 2020). The long momentum of curriculum is evident as formerly published textbooks are still being used by teachers for the preparation of teaching even after a textbook is replaced with a newer one. It is possible to expect that this trend will continue with the oldest textbook being replaced by other teachers. Teachers have probably gotten used to their school's curriculum during their teaching practice. In this sense it seems problematic, that only in the group of teachers with more than 10 years of practice could the majority of them choose a textbook themselves. Other teachers use textbooks which were already available in their school, which is also a trend in other countries (Bizzo et al., 2007). For the possibility of implementing innovations, this finding is an important indicator of a need to support freshman teachers who are forced to follow curriculum chosen by their predecessors or older colleagues adopting it. Also, almost 62% of the teachers with teaching practice 5-10 years use textbooks that were available at school. Nevertheless, with the aging teacher population, this group is likely to be choosing a new textbook soon. Their required conception of textbooks could therefore be of interest to chemistry textbook authors, resp. publishing houses as they are the target group of potential attempts to diffuse innovation in this area.

Self-selection was identified as a significant factor for satisfaction with the textbook in use. 43% of teachers want to provide their students another chemistry textbook. However, more than a half of these teachers did not know which textbook they would like to provide their students. Surprisingly, this also applies to 54% of freshmen teachers, that are expected to know the available textbooks from their recently finished university degree. They were presented the contemporary curriculum; however, they encounter the school curriculum after entering their practice. This finding, then, provides input to the pre-service teacher training.

#### *Limitations*

The results are affected by the research period. It was conducted right before a new edition of the FR textbook series was published in a changed form. Also, despite the sample being selected randomly, the almost 60% non-response rate suggests there might be teachers whose attitude toward textbooks and their



use is negative. Another limit of this study dwells in the research method. Triangulation with lesson observation and interviews with teachers and students is needed to gather reliable evidence about educational practice. However, the question of the many levels curricula, its perception and translation into practice is quite complicated and interpreting teachers' responses is impossible without thorough knowledge of teachers' approach towards curriculum (selection). The questionnaire survey then represents a vital initial point for further studies in this area.

## Conclusions

The presented research sheds new light on a part of lower-secondary chemistry education reality through analyzing chemistry textbooks' perception and the way they are being chosen and used by teachers. The textbook choice and satisfaction with them reflect teachers' perceived curriculum conception and may serve as an indicator of the curriculum's potential realization. In the system of commercial curriculum common in several countries worldwide, this information is vital as it shows the potential limits for intended curriculum implementation. As there were several findings from different countries similar to this research results, it is possible to generalize these limits for countries with comparable curriculum conception.

By their satisfaction with a textbook and preference in choosing their own textbook, the teachers in this research expressed an unambiguous inclination to the traditionally conceived curriculum, which is probably in line with their conception of teaching. The results show a high consistency in the respondents' opinions (regardless of their differing field of study or the length of practice). The majority of teachers prefer (to use or would like to buy) textbooks published almost 30 years ago (after two curricular reforms) or new textbooks which, nevertheless, follow the same structure. This suggests the teachers' inclination to the traditional chemistry curriculum. It is mostly their modern look which makes the teachers update the textbooks without the necessity of changing their teaching. This is also supported by another finding. The results show that teachers often use more than one textbook (including those already unavailable on the market) to prepare for their lessons. By doing so, they seem to prefer the teaching conception from the textbooks which they adopt and are likely not to abandon, even after the curriculum is reformed. This is stressed by the way textbooks are chosen by teachers. The most experienced teachers in the schools are usually responsible for the textbook choice. However, teachers' length of practice seems not to affect which textbook they would choose. More experienced teachers are mostly satisfied with the textbooks they use, whilst freshman teachers seem not to have a preference. They are therefore being formed by their older colleagues' approach and, as suggested in these research results, embrace it. This fact may be causing limitations in diffusing innovation from (pre-service) teacher training into schools as well as natural modifications which would come with new teachers.

For any change to be successful, it seems important to publish a textbook which will follow the innovations, but at the same time will be accepted by teachers despite their expectation from a textbook lagging behind the progressive conception. Publishing a revolutionary textbook with a newly-released curriculum and making the contemporary textbooks invalid would probably lead to formalisms with only limited progress. The way out of this vicious circle seems to be in gradual, well-explained and evidence-based examples of the new curriculum in practice being incorporated into in-service as well as in pre-service teacher training. Innovation in the implemented curriculum can then come through teacher education focused on the implementation of educational concepts incorporated in textbooks. This can lead to an understanding of these educational concepts, as well as their adoption and effective use in practice. At the same time, freshman teachers need to enter the practice equipped with sufficient knowledge about the available textbooks as well as with knowledge of textbook evaluation (selection) criteria, so they are not affected only by the looks but also the usability of the textbook. Moreover, it also seems beneficial to support the possibility for freshmen teachers to choose a suitable textbook as long as it is in accordance with the new curriculum.

In the follow-up research, teachers' use of particular textbook parts needs to be explained. This further deepens understanding about the chemistry instruction school reality and also helps to disclose, which parts of textbooks affect education the most. This knowledge will enable a) more complex description of the status quo and b) concrete suggestion towards new teaching materials at the brink of the new curriculum's introduction in the school practice.



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