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PRE-SERVICE CHEMISTRY TEACHERS' PROFESSIONAL VISION DEVELOPMENT: THE EFFECT OF LESSON-OBSERVATION PRACTICE

Linda Honskusová,
Karel Vojíř,
Martin Rusek

Abstract. *Ability to adequately analyze educational situations is essential not only for (pre-service) teachers' occupational decisions, but also for their own professional development. This study represents an evaluation of the observation practice aimed at pre-service chemistry teachers' (N = 12) professional vision development. They attended chemistry classes in schools, discussed them in a group and independently wrote their reflections. The effect on the professional vision was evaluated using a self-efficacy questionnaire, lesson reflections analyses and semi-structured interviews. The results showed that pre-service teachers significantly overestimated their ability to reflect on lessons, struggled with lesson analyses, failed to describe and analyze chemistry-specific content in contrast with their significant improvement in describing student-teacher interaction and teacher's activity – all with medium to large effect. Although observation practice deepened their ability to notice, pre-service teachers did not change attention to individual lesson's aspects. Lesson observation therefore seems to be a suitable means of professional vision development from the richness of observed phenomena's point of view, as well as students' self-efficacy improvement, however more research in several aspects is needed to further inform (pre-service) teacher training practice.*

Key words: *ability to notice, learning situations reflection, pre-service chemistry teacher, professional vision, teacher self-efficacy*

Linda Honskusová, Karel Vojíř, Martin Rusek
Charles University, Czech Republic

Introduction

Despite all the material support for education, teachers still play a key role in students' development since they manage educational processes and contribute to educational content's presentation in various ways. As part of the teaching profession, pre-service teachers (PSTs) need to be able to reflect on teaching and thus approach it based not only on feelings, but also on informed professional decisions.

Professional development is defined as the mediation of activities designed to guide teachers to improve their knowledge, skills and understanding of learning situations, which consecutively leads to changes in their thinking and behavior in the classroom (Ganser, 2000).

In recent years, teacher training and subsequent professional development have undergone many changes. There is a growing pressure to cultivate teachers' *professional vision* (Goodwin, 1994) and their ability to reflect on lessons or their own teaching. This process needs to be investigated, as it makes it possible to distinguish professionals from non-professionals and also professionals in different fields from each (Janík et al., 2016). At the same time, professional vision studies contribute to discovering the necessary interventions and procedural preconditions that improve teaching quality.

Recently, pre-service teacher training has been under researchers' microscope from several angles. It is for example their images about themselves as teachers (Akkus, 2013), the effect of micro-teaching (Komolafe et al., 2020), or paired peer approach on their development (Lewis et al., 2021). PSTs' training has also been focusing on their ability to notice–on the students' professional vision development as well as ways to foster it (Janík et al., 2019; Rusek et al., 2016; Simpson et al., 2018). This study followed in this direction. It was built on several key aspects generally associated with PSTs' professional vision development: the ability for PSTs to competently perceive the teaching process (Schwindt, 2008), respectively equipping PSTs with the *ability to notice* (Janík et al., 2016; Sherin & Es, 2005; Vondrová & Žalská, 2015); i.e., their ability to reflect on teaching by using annotation, analysis, and alteration (Slavík et al., 2014) during lesson observations.

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Professional Vision

One of the professions' characteristics is *professional vision*, defined by Goodwin (1994) as a set of discursive practices to see a meaningful event varied from profession to profession. The concept of teachers' professional vision is a relatively intensively researched issue (Scheiner, 2020; Simpson et al., 2018; Simpson & Vondrová, 2019; Stürmer et al., 2016). Sherin (2007) listed two components of professional vision: a) identifying professionally relevant events based on knowledge (*selective attention*), b) thinking about identified situations and recognizing their context (*knowledge-based reasoning*). Minaříková and Janík (2014) added other concepts such as competent teaching perception or productive reflection which then leads to the 3A methodology (Slavík et al., 2014).

The most common way to develop professional vision is to work with various electronic environments: Observer (Stürmer & Seidel, 2017), Videoportal (Krammer et al., 2008), IVŠV Videoweb (Minaříková, 2011), or video clubs (van Es & Sherin, 2008). This research focused mainly on factors influencing professional vision, the possibility of supporting its development, and the nature and structure of professional vision. The most frequently used methodological tools and methods of collecting data include video recordings of teaching, content analysis of written narratives, questionnaires, individual or group interviews (focus groups).

With respect to video lesson observation, Marsh and Mitchell's (2014) review showed a positive effect for asynchronous lesson observations on pre-service teachers' ability to link theory with practice, to develop pedagogical language, or to promote collaborative learning through communities. In addition, Liang (2015) showed that video lesson observation eliminates the negatives of in-classroom observations by reducing reactivity, subjective judgements on one hand and increasing feedback sources on the other.

In recent years, eye-tracking has also begun to be used in research into professional vision (van den Bogert et al., 2014). As a research trend, it can be observed among other things, including the effort to introduce mixed research designs–e.g., using 360-degree video (Theelen et al., 2019).

Yet, completed research suggests that PSTs or novice teachers focus on factors such as teacher activity (Sönmez & Hakverdi Can, 2012), classroom management and do not have much domain-specific vision–they rather reflect on the teaching in time than focus on professionally significant events (van Es & Sherin, 2002). Seidel et al. (2011) explored the various fields of teacher's professional vision–the Mathematics and Science respondents achieved worse results than Humanities respondents, regardless of the observed lesson's topic.

Research on professional vision has been carried out with Mathematics and Science PSTs (Seidel et al., 2011; Sönmez & Hakverdi Can, 2012; van Es & Sherin, 2008) as well as primary education teachers (van Es & Sherin, 2006). The studies of their professional vision have usually been descriptive in nature and focused on the difference between PSTs' initial and final state of professional vision. However, these studies have missed qualitative insight into such professional vision forming. There is a lack of sufficient information describing the process of professional vision development and a thorough description of input and output states from the pre-service chemistry teachers' perspective.

In the last few years, however, researchers have begun to focus on other topics, which open up new potential areas of research. Simpson et al. (2018) have suggested that teaching practice has no effect on PSTs' *ability to notice*. Conversely, choosing the video they work with as an observation does. Furthermore, it has been shown that although feedback from peers can help in professional vision development, expert feedback is necessary (Weber et al., 2018). At the same time, it is important to emphasize that it should be constructive support, not overwhelming criticism (Češková, 2020). Learning to give and receive such feedback in one's own teaching and its improvement is another important key of teacher training.

In a previous study with pre-service chemistry teachers, Honskusová et al. (2018) have found the PSTs paid the most attention to the students' learning activities and pedagogical communication and interaction. Not even a third of the PSTs' written lesson reflections included learning objectives. Also, considerable individual differences between PSTs, both in terms of initial skills to reflect on teaching and the possibilities of cultivating these skills/abilities have been found.

Teacher's Self-Efficacy

Self-efficacy plays an important role in professional skills' development. Bandura (2006) has defined it as a social cognitive theory emphasizing the development and transformation of how people influence their activities in some way–i.e., how they organize, how proactive they are, their self-regulation and self-reflection. At the same

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time, it affects how much effort and time they then devote to solving problems when confronted with complications (Pajares, 1997).

One of the many challenges contemporary teachers face, is adapting to students and incorporating student-centered teaching strategies and methods to promote independent learning (Baeten et al., 2016; Sin, 2015). *Teacher self-efficacy* can thus be understood as individual teachers' belief in their own ability to plan, organize and carry out the activities required to achieve the set educational goals. Its effect on student outcomes (Ross, 1992; Skaalvik & Skaalvik, 2007), occupation satisfaction (Caprara et al., 2003), teaching devotion (Coladarci, 1992) and higher levels of planning and organizational abilities (Allinder, 1994) have been found in several studies.

Bandura (1997) has mentioned four areas that help support higher levels of self-efficacy. These include a situation where the teacher applies a previous successful procedure (*mastery teaching experience*), emotional support from colleagues (*social persuasion*), and observing their colleagues' effective work performance (*vicarious experience*). All these components positively affect the so-called physiological and emotional states. It is clear from the above that at least one of these components is also supported by procedures aimed at developing professional vision. For this reason, it is appropriate to also monitor this domain with chemistry PSTs. This approach could help increase the number of graduates from teacher training programs focused on chemistry teachers who actually enter the profession and remain teaching.

Lesson Reflection and 3A Methodology

The effect of professional vision on teachers' performance is being mirrored in their ability to reflect on (their) lessons. Reflective thinking depends primarily on the individual activity (Gelter, 2003). Therefore, cultivating chemistry PSTs' reflective thinking is useful because it allows them to flourish in identifying, analyzing, and solving complex problems that commonly arise during teaching (Spalding et al., 2002). Dealing with and solving critical moments leads to improvement and thus teachers' professional growth, as reflective practice allows PSTs to acquire the knowledge needed to make their pedagogical decisions for themselves (Francis, 1995). As a result, this knowledge generates other new questions that lead PSTs to change the way they conduct teaching, how they respond to criticism, and their social and cultural beliefs (Liston & Zeichner, 1990). At the same time, PSTs also need opportunities to interact with other colleagues/peers during (group) reflections to be forced to formulate their own beliefs and understand their new emerging concepts and expertise. Environments that create opportunities for social interactions and collective efforts to take place allow PSTs to better understand and critically accept new concepts (Danielewicz, 2001).

The presented study also uses the 3A methodology, which aimed to support teachers' professionalism in terms of their experience with a certain degree of professional understanding. It leads to their ability to recognize moments that require improvement. This needs to be equipped with appropriate knowledge. 3A methodology is based on the *model of educational reconstruction* (Komorek & Kattmann, 2008) and works with three known areas of didactic research: (1) studying students' ideas about subject content, (2) domain specific content analysis and interpretation, (3) teaching environment, respectively interconnected processes for student learning and teacher action. The third basic starting point is the *methodology of critical didactic incidents* (CDI) (Hughes, 2007; Slavík et al., 2017). The analysis focuses on the essential elements of ongoing activities (*critical elements*) - targeting description of those situations in which success or failure is clear. The overall design of the didactic case study then follows this pattern (Janík et al., 2019): annotation (describing the context of the teaching situation and subject-matter's didactical conception), analysis (content structure and content transformation analysis), alteration (quality assessment, alteration design and review). This methodology has proved successful in sharing knowledge in the professional communities (Janík et al., 2019) and has already found use in research articles focused on: chemistry (Rusek et al., 2016), biology (Pavlasová, 2017) and others (Vondrová & Žalská, 2015).

Research Aims and Questions

The aim of the presented study was to find out how developed chemistry PSTs' professional vision was at the beginning of their specialized study (the follow-up master's study, the first year focused on teacher training) and what steps lead to its improvement. The set of particular steps was concentrated under the *Observation Practice Course* - a one semester long university course focused on PSTs' professional vision development. The opportunities for professional development of chemistry PSTs have not yet been characterized. Since professional development

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courses seem to be effective in other domain specific fields (Minaříková, 2014; Sönmez & Hakverdi Can, 2012), the same was therefore applied to chemistry teachers as a separate group (Honskusová et al., 2018).

To map the issue regarding the possibility of targeted interventions, it is necessary to find out PSTs' skills, their initial abilities, as well as effective mechanisms for their further progress. For this reason, the following research questions were formulated:

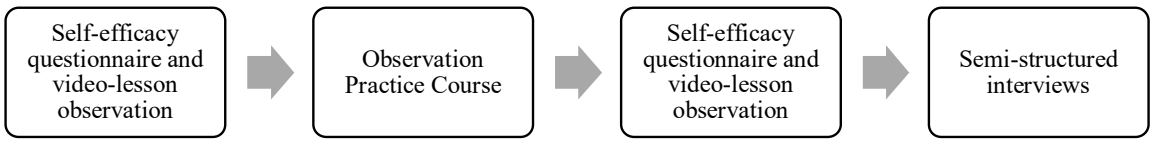
- RQ1: What is the effect of the Observation Practice Course on chemistry PSTs' ability to reflect on lessons?
- RQ2: What is the effect of the Observation Practice Course on chemistry PSTs' self-efficacy with respect to their ability to notice?
- RQ3: What kind of support measures are perceived by chemistry PSTs as sources that contribute to their professional development?

Research Methodology

Research Design

This study included several related parts in order to answer the research questions, i.e., to map the effect of field-didactic training with a focus on professional vision development and reflective practice–see Figure 1. The study consisted of a teacher self-efficacy questionnaire and a video-lesson reflection (both input and output). Semi-structured interviews were included to obtain additional qualitative information.

Figure 1
The Scheme of the Research



Research Sample

The sample of this study represents an available sample of the entire student class. Lower- and upper-secondary school chemistry pre-service teachers (N = 12, 9 female) attended the course in the first year of their master's studies at the Faculty of Education, Charles University (Czech Republic), during the first semester in 2018. They studied a chemistry program combined with biology, health or mathematics education. With one exception, all respondents completed bachelor studies in chemistry focused on education. The PSTs completed pedagogical and psychological subjects or compulsory elective courses (22 credits; a total of 86 credits for study) in addition to the courses focused on the subject domain (59 credits for chemistry + 5 credits for chemistry didactics). As part of general pedagogical and psychological training in the follow-up master's studies, the PST had already completed: *Pedagogical and Psychological Practice with Reflection*, *General and School Didactics*, *Educational and School Psychology*, subject-oriented didactics for primary schools (chemistry + mathematics or biology or health education)–approx. 17 credits, in addition to strictly chemistry subjects (5 credits). At the same time, some of the PSTs had already taught in a lower-secondary school or led a science class. Two PSTs underwent a video course in another department during the semester.

Observation Practice Course

The *Observation Practice Course* consisted of several school visits, during which PSTs observed real lessons. Afterwards, they analyzed them with the teacher instructor using the 3A methodology (Slavík et al., 2014). The first lesson was taught by the chemistry teacher at the visited school, one lesson by the Observation practice course's instructor and the remaining lessons by the PSTs themselves teaching in tandem. Each session had a short group reflection, then the PSTs wrote their own lesson reflections.

Nine reflections were obtained from each PST: initial and final reflections, which were written on the same

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video lesson, together with the reflections from the attended lessons. Altogether, 99 written outputs were obtained. For this study's purpose, the video lesson's reflections were included (22 in total).

The change in PTSs' perceived ability to reflect on teaching (i.e., annotate, analyze, alter) was assessed using a teacher self-efficacy questionnaire filled in at the beginning and at the end of the course. The global picture of the course's impact on the PSTs was then completed by their opinions about its function.

Teacher Self-Efficacy Evaluation–Ability to Reflect on Lesson

A questionnaire based on Bandura (1997) was used to analyze the PSTs' self-efficacy in terms of their perceived ability to reflect on teaching. Designing the tool, Bandura's recommendations for formulating the statements were followed. In the questionnaire, the PSTs expressed the degree to which they agreed with the statements on a 4-point Likert scale (true, rather true, rather false, false). The tool consisted of two separate parts (see Table 1).

Table 1
Statements and Their Individual Completions in the Teacher Self-Efficacy Questionnaire

Part	Statements in the questionnaire	Individual items
1	I am convinced that I am capable to...	objectively describe the observed lesson in detail, evaluate the observed lesson, evaluate the classroom climate, propose appropriate changes, monitor teaching conditions, evaluate the quality of communication, analyze the use of teaching aids and instructional materials
	I am convinced that over time my ability to...	reflect on teaching will improve
2	I am convinced that I am able to objectively describe... I am convinced that I am able to objectively analyze... I am convinced that I am able to objectively propose changes...	curriculum, lesson goals, methods, organizational forms, motivational elements, methods and tools for evaluation, application of classroom management

The first part focused on the ability to reflect on selected aspects of teaching. The second part focused on their ability to reflect on the educational content and its mediation, i.e., the implemented curriculum. This aspect was monitored in three levels corresponding to the 3A methodology: annotation, analysis, and alteration (Slavík et al., 2014). The observed components were chosen based on general didactic/pedagogy literature (Kalhous & Obst 2009; Pasch et al. 1995).

Reflective Skills' Analysis

Chemistry PSTs at the beginning and at end of the course (October 2018–January 2019) individually reflected on a video recorded chemistry lesson, which they watched during the course lesson. The video captured a lesson at an 8-year grammar school. It focused on the topic of homology series and gaseous hydrocarbons.

The PSTs' reflections were considered a series of separate statements. Their complexity was operationalized in terms of *information or idea units* (so-called IUs) (Ellis & Barkhuizen, 2005). These IUs provide a measure of the extent to which a speaker/writer encodes the ideas needed to communicate the content. The first to present these information units were Chafe and Danielewicz (1987), who defined IUs as 'bursts' of spoken language representing all content of the speaker's thoughts. IUs thus represent the content of speakers' thoughts.

Each of the reflections was thus divided into information units. To ensure the correctness of the classification, the segmentation was checked by a second independent researcher. The determined information units were then classified by two independent evaluators according to the established system of categories (see below).

The construction of the coding tool for reflection analysis was based on the methodology by Sherin and Van Es (2009) supplemented by the dimensions of the model based on Shulman (1986) (*Pedagogical Content Knowledge*, PCK) and by aspects of 3A methodology (Janík et al., 2019). The resulting tool contained the following items (Table 2):

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Table 2
Categories Used to Classify Information Units Regarding Professional Vision Components

Professional vision component	Dimension of analysis	Coding categories	Depth of parsing
Selective attention	Actor	Student/s	
		Teacher	
		Student/s + Teacher	
		Not identified	
	Pedagogical Content Dimension	Content Dimension (Chemistry)	
		Pedagogical Dimension	
		Pedagogical Content Dimension (Chemistry Education)	
		Not distinguishable	
Knowledge-based reasoning	PST's parsing strategy	Annotation	Lower
			Higher
		Analysis	Lower
			Higher
		Alteration	Lower
			Higher

Actor. In their written lesson reflection, the PSTs described the teacher (T; "The teacher paid attention to safety rules during the experiment."), the student/s (S; "Then the students listed the various characteristics they observed and assembled them together.") or the student/s and the teacher at the same time (ST; "They analyze the characteristics of what they saw together and write them on the board."). If the actor was not specified/expressed (usually the sentence written in a passive voice), but was relevant, it was derived from the context, ("Moving to a workbook and assigning a task leads to further independent work and training." - ST). The last category served for IUs which could not be positively identified (NI) from the actor's point of view, e.g.: a header (formatting of the document), which contains the place or time of teaching, time allowance, length of teaching, educational content, topic, forms and methods of teaching, events outside the window, etc. ("The lesson took place at the grammar school." or "The lesson topic was introduced and discussed in the previous lesson."); the PST's opinion ("I liked the lesson very much, if I were at least half such a teacher, I would not be angry at all.").

Pedagogical Content Dimension in this research was understood more broadly and does not focus only on the actor–teacher (as is typical for the PCK model). Individual categories were assigned to all coded IUs. The IU belonged either to:

- the statement regarding content dimension/chemistry ("The terms homology series, greenhouse effect, melting point, boiling point were used in the lesson." or "There is nothing more to say–only it should be said that, for safety reasons, natural gas is enriched with sulfone."),
- pedagogical dimension ("A large period of time was devoted to independent work, which emphasized the students' own thinking about the problem and awareness of the context, leading to a deeper understanding."),
- pedagogical-content dimension ("Teacher guided the entire student work by explaining and by mentioning properties into contexts, including intersubjective ones - physics, a comparison of the density of methane and propane-butane with air.") - i.e., a unit that mentions pedagogical skills but also subject content.
- The category "not distinguishable" was used to indicate an IU that was irrelevant to the analysis from the point of the pedagogical content dimension ("*Thumbs up.*").

PST's parsing strategy. The PST annotated, analyzed or altered in the given information unit. The individual categories in the PST's approach were further divided into two levels according to the depth of the analysis:

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- Annotation–selective thought image of the teaching situations (teaching goal, topic, content, didactic approach–i.e., the activity of the teacher and the student/s):
  - lower - only descriptive IU, no further description ("*Teacher asks questions*," or "*Teacher discusses hydrocarbons*.");
  - higher - within the annotation the PST gives specific examples of events, activities of student/s and teacher, specifically describes activities, etc. ("*The teacher examines how students think and what they imagine/what is low melting point for you?*" or "*Teacher introduces the hydrocarbons in connection with the things they know —propane-butane bombs, natural gas— and tries to find out what the students know about it.*").
- Analysis–assessment and analysis of the connections between the educational content, goals and students' activities (e.g., place, time, content, distribution of activities in whole lesson):
  - lower - formulated as an opinion, usually expressed by an evaluative adjective, without relying on a theoretical framework and without a professionally correct context ("*At the end of the lesson, teacher assigns a few homework exercises, in my opinion a large amount*."), or the PST determines the type of learning situation (failing, underdeveloped, stimulating, developing);
  - higher - an effort to clarify the learning situation in the context of teaching process ("Whether the lesson objectives have been met, I cannot judge, because I did not have the opportunity to get acquainted with the preparation for the lesson...").
- Alteration–proposals of changes towards the teaching procedures that would be desirable - to address a critical moment in teaching, based on the analysis:
  - lower - the PST only suggests changes ("The only thing I might do is that before injecting butane into the beaker, I would show that there is nothing that can burn.");
  - higher - the PST proposes changes, including arguments or comparison of alternatives, or justifies the argument, which cannot be stated without a theoretical framework ("*The teacher could ask who thinks that the methane is lighter/heavier than air to activate the whole class and then ask who can explain why they think so.*").

Separate information units were determined based on a shift in focus (change of attention) in the text analysis, i.e., the information unit is a comprehensive statement focused on one specific micro-situation. However, if there was a change in the 3A category (in a given unit), the segment became a new information unit. Lesson reflections' titles were not coded as IU ("*Reflection-chemistry lesson*"), it was only the introductory sentences ("*The video was focused on the chemistry lesson of grammar school students*").

Interviews

The semi-structured interviews were conducted with 11 PSTs (February to May 2019). The interviews were based on 7 questions focused on: 1) what phenomena PSTs noticed during the lesson observation, 2) what system PSTs followed during the lesson observation 3) how PSTs changed their approach toward observation and reflection since the beginning of the semester, 4) what other courses focused on didactics/observation/teaching analysis PSTs took, 5) how PSTs perceived their shift in the ability to observe lesson, 6) how PSTs perceived their objectivity of lesson observation and reflection, 7) what PSTs perceived helpful for their observation and reflection skills development. Interviews were recorded and transcribed into a text editor and then subjected to qualitative analysis using open coding (cf. Blair, 2015; Strauss & Corbin, 1990).

Data Analysis

The data from the questionnaire arose from the PSTs' answers to the given statements on rank scales. They were considered as ordinal and treated accordingly. To analyze the data, MS Excel and an online tool available at www.ai-therapy.com were used. For the second part of the research instrument, the reliability was assessed using Cronbach's alpha coefficient: initial reflection –annotation ($\alpha = .736$), analysis ($\alpha = .935$), alteration ($\alpha = .941$) and final reflection–annotation ($\alpha = .916$), analysis ($\alpha = .938$), alteration ($\alpha = .931$). These values can be considered acceptable (Tavakol & Dennick, 2011) and the tool reliable. Thus, all items were considered in the scales' assessment.

Reflections were acquired from 11 PSTs (one PST had an individual study plan). For consistency in evaluating PSTs' written reflections (initial and final) by two researchers, the Cohen's kappa values for the evaluators' agreement

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were assessed (Landis & Koch, 1977; Matthijs, 2010). For each dimension: *Actor* (κ = .749), pedagogical content dimension (κ = .673) and 3A (κ = .789) kappa values for all categories indicated substantial agreement (see Landis & Koch, 1977) and could therefore be relied on. In the case of disagreement between the two researchers, the IU was included after a joint discussion (*consensus by agreement*) in terms of peer debriefing to reach an agreement for the coding (Creswell & Miller, 2000).

To assess the difference between the initial and final teacher self-efficacy questionnaire (all items in Part 1 and the scale values in Part 2) and for initial and final reflections, a non-parametric Wilcoxon Single Rank Test was used with respect to the nature of the data. The *p*-values are reported to show the level of statistical significance. To assess the effect-size the *r* coefficient was used (Cohen, 1992).

Research Results

PSTs' Initial and Final Level of Ability to Reflect on Lessons (RQ1)

The reflections of all the PSTs after the course contained more IU than before. While the input reflections contained from 8 to 23 IU (in total 135 IU), the final reflections contained from 16 to 33 IU (in total 274 IU). Thus, all PSTs had longer reflections at the end of the course. An overview of the IUs' frequency in individual analyzed dimensions is introduced in Table 3.

Actor. The data in table 3 show that when entering the course, PSTs paid slightly less attention to *teacher* activities (33.3%) compared to *student/s and teacher's* activities (38.5%). The final reflections' analysis (written after completing the course) showed a statistically significant difference ($z = 2.807$, $p = .005$) in the proportion of statements including both activities *student/s and teacher's* (increase in proportion by 11%; 4.2 pp) with a large effect-size ($r = 0.598$). The decrease in proportions by 4.8 pp was also significant for the *teacher* category ($z = 2.094$, $p = .036$), with a medium effect-size ($r = 0.446$). In contrast, no statistically significant difference was found for the *student/s* category (8.9% IU initial reflection and 9.1% IU final reflection).

Pedagogical content dimension. In the area of pedagogical content dimension, significant differences with a large effect-size in reflections (initial and final) were found in the areas of PD ($z = 2.937$, $p = .003$; $r = 0.626$) and PCD ($z = 2.810$, $p = .005$, $r = 0.599$). After completing the course, the proportion of statements in the PSTs' reflections changed. An increase in the frequency of IU in both areas was found.

Table 3
An Overview of the Frequency of Information Units in Individual Analyzed Areas

Dimension of analysis	Coding category	Initial reflection 135 IU		Final reflection 274 IU	
		Absolute frequency	Relative frequency [%]*	Absolute frequency	Relative frequency [%]*
Actor	Teacher	44	33.3	78	28.5
	Student/s	12	8.9	25	9.1
	Student/s + Teacher	50	38.5	117	42.7
	Not identified	29	19.3	54	19.7
Pedagogical Content Dimension	Pedagogical Dimension	57	42.2	126	46.0
	Content Dimension	0	0	6	2.2
	Pedagogical Content Dimension	71	52.6	131	47.8
	Not distinguishable	7	5.2	11	4.0
PSTs parsing strategy	Annotation	94	68.9	172	62.8
	Analysis	41	31.1	85	31.0
	Alteration	0	0	17	6.2

Note: *Percentage values express the mutual proportion (relative frequency) of all IUs for a given area of analysis (i.e., they form 100% in a given category).

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Although no statistically significant differences were found in the other categories, an increase in IUs was noted also in the *content dimension* category (+ 2.2pp). These statements mentioned *teacher* or did not include the actor at all. They thematically focused on demonstrating an experiment ("*The only thing I might do is that before injecting butane into the beaker, I would show that there is nothing that can burn.*") and occupational safety.

Despite the fact there were no significant changes in the *student/s* category, a deeper examination of the category showed that there was a significant increase in the pedagogical dimension. After completing the course, PSTs focused more on the area of pedagogical phenomena and interactions, a shift was noticed from 3 IU (25%) to 17 IU (68%). This represents a statistically significant difference with a large effect-size ($z = 2.392$, $p = .017$, $r = 0.510$): "*The students seemed active and attentive with enthusiasm for the topic.*" or *"Students had plenty of time for all the activities".* At the same time, there was a decrease in IU proportion concerning chemistry education (pedagogical content dimension); it decreased from 75% to 28%.

3A–annotation, analysis, alteration. Analyzing the PSTs' reflections, which were elaborated at the end of the course, showed a statistically significant difference with a large effect-size of IUs devoted to annotation ($z = 2.943$, $p = .003$, $r = 0.627$). In analogy to the previous dimension (pedagogical content dimension), it was found that during the course, the somewhat developed PST ability to annotate the observed lesson was further improved. Therefore, it seems rational to focus more on analysis and alterations during adjustments in the course(s) focused on the PSTs' professional vision development. However, even then, a significant difference with 1a large effect-size was found, both in the ability to analyze ($z = 2.443$, $p = .015$, $r = 0.521$) and alter ($z = 2.588$, $p = .010$, r = 0.552). In the case of IUs coded as *analysis*, an absolute increase in frequency was noticed, caused by the overall increase in IUs in the PSTs' final reflections. In the case of alterations, however, there was only a 6.2pp increase in the final reflections, as statements of this type did not occur in the initial reflections. Statements in the final reflections regarding alterations mainly concerned curriculum presentation ("*new word - foreign, complicated - she could write it on the board - later from the class there was a question what that word was*") and its transformation ("*she could take it through the molecule straight away, it would save time, but the students figured it out on their own anyway*"). As it turned out from the interviews with PSTs, alterations are more difficult for them. They also stated that if they were satisfied with their analysis of the observed lesson, it was easier to suggest these alterations. The interviews also showed the reason for the low alteration occurrence in the reflections. The PSTs reported their limited experience with examples of good practice, according to which they would formulate their alterations.

A statistically significant difference with a large effect-size ($z = 2.720$, $p = .007$, $r = 0.580$) was found in the *annotation* category of *student/s and teacher* in the analyzed reflections written after completing the course. This increase was, again, given by the total amount of IUs. However, the *Student/s + Teacher* category was the only one where an actual increase in the UIs' proportion was noticed (from 52 to 117 IU).

In the *pedagogical dimension*, the number of IUs in combination with all categories of *3A dimension* has increased through lesson observation practice. A significant difference with a large effect size was found in annotation in *pedagogical dimension* ($z = 2.610$, $p = .009$, $r = 0.556$) and significant differences with a medium effect-size were found in analysis in *pedagogical dimension* ($z = 2.299$, $p = .021$, $r = 0.490$) and alteration in *pedagogical dimension* ($z = 2.232$, $p = .026$, $r = 0.476$).

The PST Training Course's Effect on Pre-Service Chemistry Teachers' Self-Efficacy (RQ2)

This part provides more information about the PSTs. In the questionnaire taken at the beginning of the course, they expressed their perceived ability to describe lessons, as well as to suggest appropriate changes (*med* 3) or observe the classroom climate (*med* 4) to be at a good level. The PSTs also felt equally competent regarding individual lesson analysis areas: perceived ability to annotate (*Anno*), perceived ability to analyze (*Ana*), perceived ability to alter (*Alt*) - all *med* 3. At the same time, they believed their ability to reflect on lessons would increase (*med* 4). In the questionnaire taken at the end of the course, the PSTs still considered their ability to reflect on teaching/lesson to be at a good level. There was a statistically significant difference with a medium effect-size found in the PSTs ability to describe observed lesson in detail ($z = 2.271$, $p = .023$, $r = 0.464$) and ability to evaluate the quality of communication in observed lesson ($z = 2.121$, $p = .034$, $r = 0.433$). A statistically significant difference with a large effect-size was found in the PSTs ability to propose appropriate changes ($z = 2.449$, $p = .014$, $r = 0.500$) and ability to evaluate the classroom climate ($z = 2.646$, $p = .008$, $r = 0.540$).

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PSTs' belief in their possibilities to improve their lesson reflections remained at a high level (*med* 4). Additional interviews (see below) showed that they had no idea in general how to analyze lessons and overestimated their abilities when entering the course (regarding thinking about teaching/learning). The fact that there was no decline observed in this item after the course ended, shows the course's positive effect.

PSTs seemed to be more confident about their ability to evaluate lessons at a general level (*med* 3 to 4). Hence, it seems that the course had a significant effect on their self-efficacy regarding their ability to notice. The above-described shifts were due to several factors. In the interviews, the PSTs mentioned repetitive observations, group analysis, writing reflections and focus groups as supportive steps. At the same time, the PSTs considered their previous internship (or ongoing employment as a teacher) helpful.

As far as the scales regarding 3A were concerned, a statistically significant difference with a large effect-size in all three areas was found: *annotation* ($z = 2.849$, $p = .004$, $r = 0.582$), *analyze* ($z = 2.943$, $p = .003$, $r = 0.601$) and *alterations* ($z = 3.068$, $p = .002$, $r = 0.626$). The PSTs considered their ability to annotate, analyze and alter lessons significantly better after the course finished. It suggests the course's effect on PSTs' self-efficacy improvement was considerable.

The follow-up interviews showed the PSTs considered annotation to be the easiest aspect of the lesson reflections (12 out of 12). They felt most confident in this phase of lesson reflection, some of them even perceived improvement in this ability (they stated that the course helped them pay better attention to specific teaching phenomena and to segment a lesson more efficiently). The information above, however, showed the confidence did not always meet the desirable outcome.

Three PSTs mentioned the analysis as the key part of their reflection process. These PSTs considered this part the most difficult, mentioning that when observing a lesson, they often did not know the lesson's goal, did not know the students nor the context of their learning process, and that for an ideal analysis it is necessary to understand the teaching unit in the context of these elements.

Support Measures Contributing to PSTs' Professional Development (RQ3)

The effect of the course (RQ3) was already shown in the passages above. It was also completed by the information from the last part of the interviews with the PSTs. It focused on the measures they considered supporting in the course. Several measures the PSTs perceived as supportive for their development in reflecting on lessons were identified: collective analysis with a course instructor (12), group discussion - other PSTs' opinion (9), writing reflections (5), the opportunity to teach as a first experience (2), regularity and feedback (1), observing other PSTs - not only teachers from practice (1). These results showed the students mostly appreciated the course's structure.

Discussion

Ability to Reflect on Lessons

The finding that PSTs focus often on teachers when observing lessons agrees with other studies (Hammer, 2000; Minaříková, 2014; Pavlasová, 2017). This phenomenon is common, especially for pre-service or novice teachers (Star & Strickland, 2008). As the current trend in education is to focus more on students and their activities (student-centered education) (Kaya, 2008; Sin, 2015), it is appropriate to guide PSTs in this direction. However, this is unusual compared to the common trends for PSTs, who usually focus on the teacher as an actor (see above). The category student/s and teacher did not allow us to distinguish whether the PSTs focused on both actors more precisely, as students' and their teacher's activity was similar/synchronic or because the teacher is the main actor. For this reason, examples of student-centered units need to be shown to PSTs in order to direct their attention. In the reflection analysis, this was partly a linguistic problem amplified by the specificity of a particular language, which can be considered a limiting factor of the used methodology, yet one which cannot be bypassed.

The data suggest that in the areas PSTs noticed in the initial reflections, their skills deepened. This aligns with findings of Muhonen et al. (2021) and suggest the course was effective. Their study showed a negative association between teaching experience and pedagogical content description and pedagogical/conceptual

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explanations, which suggested, that PST are able to notice pedagogical domain more implicitly, without exceptional effort. Conversely, in the not implicitly automatic areas, they remained undeveloped (also cf. Berliner et al. (1988)). Furthermore, Star and Strickland (2008) found that PSTs largely did not notice subtleties in the ways that the teacher helped students think about content. A comparison of the PSTs' and an expert's reports could bring more clarity into this issue.

Nonetheless, the results showed the students did not develop homogeneously in these already developed categories. The observed significant increase in the *pedagogical dimension* suggests that the pedagogical aspects of teaching were perceived most strongly by the PSTs. They focused mainly on whether the lesson was functional, what the course of the lesson led to and what the teacher's activities were. With respect to the didactical courses, these PSTs had undergone, it is flattering they abandoned the typical traditional approach (cf. Johnstone, 1991) and analyzed the lessons through the lenses of the curriculum, which uses the content of education as a means to achieve key competencies. They thus reflected the educational content, methods, and teaching forms, but did not link key competencies with subject goals. This suggests PSTs struggle to spot field specifics. Although a major part of their undergraduate studies is field-oriented, they were unable to reflect the content knowledge into the lesson analysis. Alternatively, they can reflect the educational goals and their transformation (which they could already do at some level when entering the course), but could not relate the same noticing toward the student/s.

The data support that PSTs are able to improve in dimensions that are natural for them to observe and have developed more in those areas during the course, but they lack a more comprehensive view of the field they are studying (subject specific domain). It will probably come after they undergo their in-service practice with reflections, which would be worth studying in the future. Nevertheless, this aspect needs to be closely watched and targeted in the PSTs' reflections. Also, greater cohesion of chemical courses respecting these goals of teacher training would help develop the PSTs' noticing. With respect to these reoccurring findings, the risk of novice teachers impersonating their teachers needs to be eliminated. The ill-founded, sometimes even counterproductive grip on the traditional conception of teaching (Johnstone, 2010) seems to be passed from older teachers to their young disciples. Without them being equipped with strong enough observation skills and inner system, there seems no way out of this vicious circle.

Increase of the IUs was recorded especially in relation to science specific area - experiments. In the light of recent research (Rusek et al., 2020), such situations are rare in chemistry lessons. For this reason, chemistry content noticing needs to be explicitly emphasized to the PSTs. In this respect, Němečková (2019) found that both pre-service and in-service teachers in her study had low rate of the subject category, which means that they are not focused on the subject and subject didactic in pre and even post-reflections. It seems, that in-service teachers use more episodic knowledge, content knowledge, and pedagogical content knowledge to explain the observed classroom situation (Gegenfurtner et al., 2020).

Self-Efficacy

The increase in the perceived ability to evaluate the classroom climate may be due to repetitive lesson observations, which led to the PSTs' better focus on details - observations became a routine activity for them, so they were able to observe other factors and employ their own emotional intelligence better. This can be explained by Martins et al. (2015) results who found that self-efficacy perceived higher by PSTs is primarily associated with interpersonal relationships and discipline maintenance in the classroom. These results point to the PSTs' difficulties in tasks involving pedagogical knowledge as opposed to tasks related to their relationship with students.

The PSTs self-efficacy was already relatively high at the beginning of the course. When compared with their lesson observations, however, the overestimation of the PSTs' skills was evident. Bandura (1997) suggested that a slight overestimation of one's own abilities can be beneficial and leads to greater effort and perseverance. On the other hand, excessive overestimation can in the future lead to blaming their own students or ignoring ideal opportunities for professional development and therefore must be worked with. Interviews with the students showed, they soon understand the limits of their own skills, therefore would change their responses if the tool was given to them later in the course.

One expansive factor the PSTs mentioned the most was a group discussion with the course instructor. They considered it important for their own study process. They also ensure the course instructor high standards of

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supervision and thus allow tailored support for the course's participants (Boz & Boz, 2010; Caires et al., 2012; Palmer, 2006).

Another factor the PSTs mentioned as helpful was their previous practice. This is in agreement with Hoy and Spero (2005). The practice probably helped them gain some perspective and control. On the contrary, other studies have shown that the PSTs' self-efficacy may or may not change during their vocational training (e.g., Lin & Gorrell (2001)). This only stresses the need of pre-service training and raises the question of further training for (novice) in-service teachers.

When considering particular steps of the lesson analysis, PSTs consider *analysis* to be most difficult. Such statements point to the PSTs' lack of ability to identify the goals or deduce the instruction based on observed student activity. This is naturally more difficult in video lessons. Also, only through a longer exposition to education do teachers gain the necessary view into typical activities and their manifestations. This area of students' skills requires a special attention by researchers. One course seems not to be sufficient for its development and following courses may not address it fully. Also, the effect of subsequent in-school practice on the PSTs' ability to analyze didactical situations remains unclear. So does the effect of this PSTs' skill on their lesson preparation.

Lower self-efficacy in terms of the ability to analyze didactical situations naturally affects the proposed alterations as only well-considered situations can be properly altered. The PSTs' often unfounded alterations (see above) proved this point. Several respondents were also not able to decide whether analysis is more complicated than alteration. A possible starting point is further segmentation of the observed lessons to individual critical situations. In such a simplified form, it seems easier to capture the whole critical incident in depth (see e.g., Češková, 2020; Rusek et al., 2016). Five PSTs mentioned implementing alterations as the most difficult, as they lack both the experience and tools at the beginning of their career – a portfolio of teaching forms and methods – to be able to suggest changes. With respect to the quality of their lesson reflection, the fact that not all the PSTs mentioned this was surprising. Despite it not being reasonable to expect elaborate alteration suggestions from students who have just started their pedagogy training, their realization of this lack in their competences is important. Only then can they work towards developing these in follow-up courses.

Supporting Measures

There were several factors the PSTs mentioned as supporting in the interviews. As mentioned above, PSTs valued discussions with the course instructor who helped them analyze particular didactical incidents. The fact only two PSTs mentioned the opportunity to teach as a supporting measure to development of their professional vision may be caused by their feeling of pressure (having to teach one semester before they are supposed to according to the study program). Similarly, Simpson et al. (2018) found no influence of PSTs' pedagogical experience on their attention. Muhonen et al. (2021) in this respect found that Finnish Grade 1 teachers showed negative associations between knowledge-based reasoning and teaching experience. On one hand, theoretical information from university courses may be better received with PSTs who are already teaching, nevertheless, the risk of them fixating practices experienced in their schooling without proper reflection from the contemporary state of the didactical art could be counterproductive.

The PSTs' perceived practicality may be an issue here. In accordance with O'Sullivan's (2003) PSTs courses' criticism, their separation from practice was addressed in the course described in this study. Being in the classroom, seeing their peers teach and being obliged to teach themselves, the PSTs lived through a deeper experience. The question of virtual lesson observations is therefore still current and discussed from various angles (cf. Liang, 2015; Marsh & Mitchell, 2014).

Limits of the Study

The results are limited by the sample size. As already mentioned, however, this was a convenient sample–all course PSTs were included. The quant-qual approach allows a deeper understanding of the studied issue. The results are also limited by the fact that the research tool for the PSTs – written reflection analysis allows the performed analysis to be coded or altered but does not allow the given content's correct didactical/pedagogical conception to be evaluated. This shows there are other opportunities for qualitative evaluation. Also, in this

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study, the PSTs witnessed mostly teacher-centered lessons which could be the reason for such a result (focusing mostly on the teacher or teacher in action with students). The selected limits were taken into account in course management in the following academic years and the course's design was improved in the light of these findings.

Conclusions and Implications

The presented study focused on pre-service teachers' professional vision development within a special-designed observation practice course. The results showed the initial PST's conception of lesson reflections is based on feelings more than imbedded in the knowledge they have been gaining during their studies - they tend to mention (and analyze) individual didactic incidents which they 'dis/liked'. However, it seems that the procedure outlined in this text led to both strengthening the objectification of such statements and to a more constructive PSTs' lesson reflection approach. Nevertheless, several critical points in professional vision fostering were identified: the course contributed to the deepening of areas in which PSTs already had a certain level of proficiency, whereas some areas remained relatively unimproved.

This study brought specific insights for pre-service teacher trainers in terms of PSTs' development in certain aspects. First, PSTs in their lesson reflections failed in the description (annotation) and analysis (and as a result also in alteration) in the subject-specific domain (chemical content) of the observed lessons, even though they have completed three years of professional study. Different ways of thinking in the social and natural sciences seem to negatively affect PSTs' thinking about chemistry in pedagogical disciplines. Because chemistry expertise and the pedagogical knowledge are often taught separately, there is no interconnection and their PCK (hence CK) is not at a desired level. This aspect can be strengthened by using videotaped lessons/pedagogical situations in which work with content offers deeper discussion. The same applies for educational situations representing student-centered lessons. Second, PSTs often do not have a sufficient portfolio of all the necessary skills and tools which appear in the observed lessons. Therefore, it is appropriate to provide them (not only) with observation tools which serve primarily to strengthen their ability to annotate and, as a result, to analyze the lesson. It would also be beneficial to design supporting materials for PSTs, e.g., in the form of an exemplary case studies – lesson reflections.

The results also revealed areas which need a special attention from the methodological point of view. First, it was proven effective to specify repeatedly found information units in the PSTs' lesson reflections in more detail to increase the coherence of two evaluators' coding. Secondly, to capture the analyzed situations in a satisfactory detail, it was found appropriate to extend the coding tool by a subcategory student/s and teacher in order to distinguish whether the author of the reflection focused on both actors, or the student/s were mentioned only because they were the subject of the teacher's actions. Also, by addition of PCK and 3A aspects, the used tool offers a more detailed specification of students' lesson reflection strengths and weaknesses which can be target in corresponding PST training courses.

These findings have been incorporated in the corresponding teacher training courses. Their effect will be presented in the follow-up study.

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Declaration of Interest

The authors declare no competing interest.

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Linda Honskusová Mgr., Charles University, Faculty of Education, Department of Chemistry and Chemistry Education, Magdalény Rettigové 4, 116 39 Prague 1, Czech Republic.
Charles University, Faculty of Science, Department of Teaching and Didactics of Chemistry, Albertov 6, 128 43, Prague 2, Czech Republic.
E-mail: linda.honskusova@gmail.com
ORCID: https://orcid.org/0000-0001-7957-7993

Karel Vojíř PhDr., Ph.D., Charles University, Faculty of Education, Department of Chemistry and Chemistry Education and Department of Biology and Environmental Studies, Magdalény Rettigové 4, 116 39 Prague 1, Czech Republic
E-mail: karel.vojir@pedf.cuni.cz
ORCID: http://orcid.org/0000-0002-7619-9891

Martin Rusek *(Corresponding author)* PhDr., Ph.D., Charles University, Faculty of Education, Department of Chemistry and Chemistry Education, Magdalény Rettigové 4, 116 39 Prague 1, Czech Republic.
E-mail: martin.rusek@pedf.cuni.cz
ORCID: http://orcid.org/0000-0002-6919-9076

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