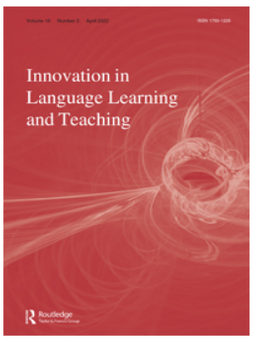

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Second and foreign language teachers' problem-solving schemata development through informal problem-solving: the relationship between experience and expertise

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ABSTRACT

Purpose: Second and foreign language (SL/FL) teachers' informal problem-solving has received little explicit research attention while it is widely acknowledged that problem-solving is crucial to expertise development in any complex knowledge domain. To develop a clearer understanding of the role of informal problem-solving in SL/FL teachers' expertise development, this study investigated how experience (i.e. time on the job) affects the level of problem-solving schemata development.

Design/methodology/approach: This situational analysis of teaching practices was conducted with 15 SL/FL teachers divided into three experience groups. Through qualitative coding of verbal reflections on teachers' own lessons, the structural components of problem-solving schemata development were explored at two levels. The first or basic level represents the broader knowledge base which problem-solving utilizes in understanding and recognizing classroom situations. The second is the expert-level problem-solving knowledge level. Qualitative codes were quantified to enable descriptive statistics and *t*-tests for the analysis regarding the basic level. A descriptive analysis was performed to uncover expert-level knowledge.

Findings and Originality/value: The results show that experience affects problem-solving schemata development in qualitatively different ways at different levels. At the first or basic level, most teachers develop extensive and numerous domain-specific problem-solving schemata with experience. Few experienced teachers develop expert-level schemata. At this level, experience mostly affects the type of domain-specific knowledge and quality of feedback on effective strategies incorporated in these schemata. The findings suggest that future studies need to adopt a multi-level analysis of problem-solving schemata development.

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Problem-solving; problem-solving schemata; teaching experience; informal learning

1. Introduction

Informal learning has been an important concept in teacher learning and in a second and foreign language (SL/FL) teaching in particular for several decades and many different aspects have been explored thus far (Kyndt and Baert 2013; Lecat et al. 2019). However, despite recent attempts (e.g. Karimi and Norouzi 2019), informal problem-solving which is one of its most essential aspects is still an under-researched topic in SL/FL teacher learning. This fact is at odds with the understanding

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that (a) problem-solving and the knowledge it involves are crucial elements of expertise and expertise development in complex knowledge domains such as teaching (Feltovich, Prietula, and Ericsson 2018) and (b) teachers are much more likely to participate in informal learning activities, such as consulting experts and expert hands-on experience or learning in communities of practice, if these activities address problems they encounter in their daily practices (Harper-Hill et al. 2020). Thus, a clearer understanding of the role of informal problem-solving in SL/FL teacher expertise acquisition and practices is needed so that such activities can efficiently contribute to this knowledge. Moreover, research on informal problem-solving knowledge can help teacher-educators understand what the most salient elements of this knowledge are so that these elements are prioritized in teacher education even before teachers begin their practices.

Informal learning is a broad concept with many varying definitions and aspects (Baert 2018). For the purposes of this study, informal learning is defined as the learning which occurs as a byproduct of teaching itself (Van Merriënboer et al. 2009). *Problem-solving* is a cyclical process in the core of informal learning which greatly defines how and what teachers learn on the job (Marsick and Watkins 2018). It is a process in which a goal is set and it is uncertain whether and how it can be achieved given relevant constraints (DeYoung, Flanders, and Peterson 2008). As SL/FL teachers spend time on the job performing their tasks, they develop knowledge called problem-solving schemata. These schemata are the knowledge units which reflect their expertise level (Nokes, Schunn, and Chi 2010). This study explores how professional teaching experience (i.e. time spent on the job) affects the development of these knowledge units, whereby this time is a proxy for the opportunities teachers have to perform regular tasks.

2. Theoretical underpinnings

2.1. Problem-solving schemata

Schemata (the singular is *schema*) are data units varying in level of specificity 'for representing our knowledge about all concepts: those underlying objects, situations, events, sequences of events, actions and sequences of actions' (Rumelhart 1980, 34). Schemata can differ in size and smaller schemata can be embedded in larger ones. *Problem-solving schemata*, specifically, are data structures which help problem-solvers recognize, understand, and solve problems (Marshall 2012). These schemata share the same declarative knowledge components as decision-making (Marshall and Seel 2012). However, while the stress in decision-making is on choosing one strategy from other alternatives when problems are perceived as known, the main functions of problem-solving schemata are recognizing and understanding problems (Feltovich, Prietula, and Ericsson 2018; Marshall 2012).

At its basic level, problem-solving schemata consist of an explicit goal (i.e. consciously accessible), factors determining situations in which the goal has to be achieved, and a problem solution (i.e. actions for achieving the goal; Bassok and Novick 2012). At this level, setting explicit goals alone creates a problematic situation since there is no guarantee that the goals can be achieved in constrained complex knowledge systems such as teaching (Stigler and Miller 2018). At expert level, problem-solving schemata also entail knowledge of specific factors called constraints (Bassok and Novick 2012). *Constraints* are factors which cause problematic situations through restricting the application of problem-solution strategies, cannot be permanently resolved within a single task or even several tasks, and are based on domain-specific theoretically valid rules and principles (Voss et al. 1983). Knowledge of constraint is crucial in complex multi-factorial situations, such as classroom teaching, since not all factors are equally relevant to judging what solutions achieve goals most effectively. Thus, at this level, 'how effective solutions are' designates the degree to which the solutions achieve the goal given a constraint. Research in social sciences posits that such schemata also entail comparative knowledge of positive and negative feedback on strategy effectiveness again in relation to constraints (Voss et al. 1983).

Research in other complex knowledge domains (e.g. arts, software design/-programming, writing, teaching) also shows that such schemata indicate presence of expert-level knowledge. For instance, Dijkstra, van der Pligt, and van Kleef (2013) compared three groups of professionals with different levels of expertise and experience regarding how their ability to deliberate (i.e. provide factors/reasons for their decisions) affects their judgement of quality of art works and musical performances. Only the experts were able to provide formally valid rules and principles to substantiate their decisions and judge accurately at the same time. Also, Liikkanen and Perttula (2009) found that although non-experts could decompose problems in software design, meaning they understood what subproblems/subgoals these problems involve, they could not define what factors were important to the problem-solution effectiveness. Recently, while cautioning that there is not a definitive definition of what an expert teacher is, Stigler and Miller (2018) used research evidence mostly from mathematics teaching and concluded that situational knowledge of factors that constrain teaching effectiveness is paramount to recognizing expertise in teaching. Such knowledge has a crucial role in judging whether a strategy for creating learning opportunities for students is efficient and while it is contextually-bound, it corresponds to theoretically valid principles.

2.2. SL/FL teachers' problem-solving knowledge, experience, and expertise

In teaching, problem-solving takes place when teachers have to resolve a problematic situation (Swanson, O'Connor, and Cooney 1990). This process has been mainly investigated through looking at the differences between the problem-solving knowledge of teachers with different experience/expertise in solving *presented problems*, that is, problematic situations normally given as vignettes to respondents to resolve (Getzels 1979; e.g. Yariv, 2013) or alternatively as problem categorization tasks (e.g. Hogan and Rabinowitz 2009). In SL/FL teaching, studies have provided more contextual validity by investigating knowledge of problematic situations in real-life classroom situations. However, these studies have shown that defining a problematic situation in real-life classroom contexts is in itself problematic and thus their results are very difficult to compare. For instance, based on coding originally developed by Gatbonton (1999), Karimi and Norouzi (2019) followed a definition which referred to problems as difficulties that the teachers had or expected to have with the lesson and the students (e.g. classes do not unfold as planned or students do not react as expected). Their study conducted among 20 English-as-a-second-language (ESL) Iranian teachers of differing experience found that knowledge of such problems was significantly larger in more experienced teachers but at some point reached a plateau. However, Wolff et al.'s (2015) study of 39 Dutch novice and expert teachers of diverse school subjects, including SL/FL teachers, understood problems as teachers' concerns about present or future classroom management situations. Classroom management was defined as all pedagogical aspects of instructional activities for achieving learning goals. The study confirmed and expanded upon previous findings that unlike novices, expert teachers were focused on student learning achievement and teachers' role in it.

Additionally, two case studies seeking to identify ESL teacher experts' characteristics provide some clues about the role of problem-solving in expert-level knowledge by stressing experts' ability to create learning opportunities. Specifically, Tsui's (2009) study compared the knowledge and behaviors of four teachers. Unlike the non-experts in the group, the expert teacher was able to recognize factors such as large class sizes or sparse use of English in students' everyday lives as barriers to students' learning and adopt strategies accordingly. Farrell's (2013) study also ascertained that the three expert teachers reflected on practice through evaluation of how effective the creation of learning opportunities for students was. In so doing, the teachers actively sought their students' assistance in solving problems. However, no specification of what this process was like was provided.

An additional insight into SL/FL teachers' problem-solving can be gained through exploring teachers' declarative knowledge of decision-making (Ogroványi-Gajos 2016). Most studies on decision-making have looked at the differences between the practical pedagogical aspects in ESL novice and experienced/expert teachers, whereby the terms experienced (i.e. >5 years' experience; see

Gatbonton 2008) and expert teacher have often been used interchangeably. In line with findings in general teaching, these studies show that unlike novices, experienced/expert teachers possess broader, more comprehensive, and integrated knowledge of students and student learning, subject matter, classroom management, and curriculum which inform their goals and activity choices (e.g. Gatbonton 2008; Mackey, Polio, and McDonough 2004; Richards, Li, and Tang 1998). More recently, however, Li and Zou (2017) explored expert, experienced, and novice EFL teachers' decision-making during planning of reading lessons and revealed that although experts and experienced non-experts had a lot in common, non-experts' decisions and reasoning were characterized with some misconceptions. For instance, both experts and experienced non-expert teachers possessed a broad range of reading techniques coupled with goals. However, unlike experts, experienced non-expert teachers often misunderstood the goals these activities pursued, meaning that they could not accurately judge the result of their planning decisions. Also, non-experts often assumed that if specific subject matter was once introduced, the instructional process did not need to involve further elaboration on it, thus exhibiting a linear vision of the instructional process.

3. The study

3.1. Problem statement, aims, and research questions

Thus far, although much is known about the basic level, most studies have exclusively focused on ESL/EFL teachers (Borg 2015; Li and Zou 2017). Thus the study aims to address this level regarding a broader group of SL/FL teachers. At the expert level, some experienced SL/FL teachers are expected to possess not only broad and comprehensive schemata but also knowledge of constraints linked to goals and problem-solving strategy effectiveness in a comparative fashion (Stigler and Miller 2018; Voss et al. 1983). Yet research is needed to explore if experienced SL/FL teachers possess such knowledge and how experience affects its development. As such, this study explores how professional experience influences the basic and the expert level of problem-solving schemata development as described in section 2.1. However, since at the basic level schemata are expected to entail only separate actions which cannot allow for meaningful comparisons, this analysis is restricted only to factors and goals. Accordingly, the study looked at two research questions:

1. Do SL/FL teachers' problem-solving schemata regarding factors and goals differ in teachers with different teaching experience?
2. Do experienced SL/FL teachers possess expert-level problem-solving schemata? If yes, how does experience affect these schemata?

Answers to these questions aim to further the discussion of what constitutes SL/FL expert teachers' declarative knowledge and its development levels as part of the triad of cognitive factors defining expertise, namely development levels, knowledge structure, and reasoning processes (Hoffman 1996). They also have the potential to uncover what elements of this knowledge are most essential in expertise development.

3.2. Respondents and context

FL/SL teachers working for Bulgarian public schools and universities were invited to participate through letters and personal visits. Teachers working for these institutions have two major characteristics in common. First, due to the liberal approach of Bulgarian educational institutions, public school teachers can decide themselves what curriculum to apply much the same way university teachers do as long as specific learning goals are achieved (Dimitrova and Kirschner 2020). Second, both groups hardly ever receive formal in-service teacher training.

Twenty-one teachers expressed willingness to participate. One male and 14 female teachers (n = 15) employed by two universities and three schools were selected as nonnative speakers of the languages they taught. Four teachers were employed by universities, ten by schools, and one by both. Two of the four university teachers reported having taught at school too. All participants were selected regarding years of professional experience of teaching general language courses (GLCs). Teaching GLCs had been their primary duty irrespective of the institution in which they worked. GLCs aim to teach SL/FL learners how to use languages for practical non-technical purposes at school and university level alike. Three teacher groups, five respondents each, were formed based on this experience. These were Group 1 (G1; M_{exp} = 1.77, SD = 0.72), Group 2 (G2; M_{exp} = 6.72, SD = 1.47), and Group 3 (G3; M_{exp} = 12.37, SD = 2.19). The between-group difference was approximately 2 years. G2 and G3 teachers formed the experienced teachers' group (i.e. >5 years' experience). The expectation was that expert-level problem-solving schemata may be observed in G3 as some experienced teachers (i.e. >10 years' experience) also exhibit expert teachers' characteristics, albeit not to the same degree (Torff 2003).

All teachers had university-level educational qualifications which are the most standard qualifications for teachers of GLCs accepted by public institutions in Bulgaria, namely Bachelor's or Master's degrees in linguistics and/or alternatively methodology/didactics of SL/FL teaching. Two participants also had PhD degrees in ethnography/biographical/literary studies, which are not part of GLC curriculum. The three groups were not further homogenized regarding educational qualifications since different universities providing SL/FL teacher education in Bulgaria/abroad have different educational plans which are impossible to compare. None of the respondents was currently following formal university-level courses or other training in SL/FL teaching pedagogy or/and linguistics. The only participant who reported participation in such formal education in the calendar year prior to the research was the participant with the least teaching experience. Formal education was defined as education which has pre-specified learning outcomes and occurs in highly structured environment designed for learning (Kyndt and Baert 2013).

Information about the respondents' demographics, education, and professional experience was collected through a questionnaire. Appendix 1 presents more details about their characteristics.

3.3. Data collection

This study analyzed teachers' reflections on recent classroom performances. Referred to here as *deliberations,* these reflections contained teachers' verbal utterances about factors or reasons for their actions/judgements (Dijkstra, van der Pligt, and van Kleef 2013) during lessons. The deliberations had to transpire in contexts with which the respondents were familiar, so that the process would come closest to how they would reason informally in their daily classroom tasks. Thus, the respondents were instructed to select one lesson which they felt comfortable teaching. This could compensate for disparities in regularity of teaching. The lesson had to (a) focus on a grammar unit or units and (b) be part of the regular curriculum for the particular group of students. Grammar was selected as it is an essential part of any GLC and narrowed down the subject matter across languages for all teachers to teaching rules and principles involving syntax, morphology, phonology, and semantics.

The lessons which the teachers eventually picked were traditional teacher-led presentations followed by practice or grammar revision with practice. The language of instruction was Bulgarian irrespective of students' learning or educational level. The subject matter included demonstrative and relative pronouns, tense formulas and uses, verb inflections, Japanese particles and conjunctions, morphology and grammatical functions, interrogative and negative sentences. The youngest students were 10–11-year-olds and the oldest were adult learners (i.e. >18 years old). They studied the languages as foreign or second. The lessons, each lasting 40 min (i.e. standard duration), were video-recorded.

Within less than 24 h after the recording, the respondents were asked to explain in Bulgarian what they were doing and what factors/reasons informed their actions while following the videos of their class (i.e. video-stimulated recall). Teachers were also asked to comment on segments/situations they found important. The procedure aimed to uncover teachers' deliberations during the interactive but also post-interactive stage. In this manner, it followed the cyclicity of the problem-solving process in which the execution of the problem solution is followed by the evaluation stage (e.g. Nokes, Schunn, and Chi 2010). However, unlike previous studies in which questions or prompts about goals, factors, or evaluations were used consecutively (e.g. Johnston and Goettsch 2000; Westerman 1991), no additional questions or prompts were employed as such are not expected to occur in informal learning conditions. The audio records of the deliberations were transcribed following Van Someren, Barnard, and Sandberg (1994).

3.4. Data analysis

The deliberations yielded transcripts which were first coded qualitatively. Then, the qualitative codes were quantified to enable statistical analysis. Here, the coding process is first described, followed by the statistical test.

To explore the first research question, problem-solving schemata were segmented in the protocols. Each problem-solving schema corresponded to a separate thematic episode and/or situation which entailed at least one explicit goal, one factor referring to the present state, and one action (cf., Wolff et al. 2015). *Explicit goals* were operationalized as intended outcomes of any given instructional activity. Both learning and activity goals (i.e. sub-goals) were coded. *Factors* were operationalized as a shorter or longer description of the reasons on whose basis goals were set and actions were enacted. The factors and goals were also coded as domain-specific knowledge categories, namely student learning, student motivation, classroom management, subject matter/curriculum issues, informed by Shulman (1987) and research data. Pedagogical content knowledge was not investigated because it is procedural (i.e. the knowledge of how; Johnston and Goettsch 2000). Actions were identified to validate schemata entirety but not further analyzed, as reported earlier.

An example of a schema taken from the protocols is presented next. It entails an explicit goal and two factors. Codes starting with '1' denote goals, those starting with '2' denote factors. The codes follow the section to which they refer and are placed between parentheses.

> Generally we're following the order [the action] in which we've introduced the cases (2.2) because
>
> At the very least this prompts them what the next case is
>
> Respectively dative and finally genitive
>
> This helps them think about the accurate case and eventually what noun gender [they need] (1.1.1)
>
> Because
>
> Some of them still have problems remembering the gender of nouns in German (2.1.1)

In the example, 1.1.1 is a goal of student learning and 2.1.1 is a factor concerning that goal. *Student learning* refers to descriptions of learning processes (e.g. strengthening students' knowledge, facilitating knowledge acquisition, familiarizing students with a new grammar unit). 2.2 signifies both subject matter and curriculum issues as factors. *Subject matter* involves any given grammar field (i.e. morphology, phonology, syntax, and semantics). *Curriculum issues* concern factors about curriculum materials such as textbooks or teacher's guides.

Another example of schemata is next presented. It entails one explicit goal and one factor. 2.1.2 stands for a factor regarding student motivation. *Student motivation* was broadly operationalized as students' behavior, beliefs, and attitudes toward the educational process. Code 1.3

refers to a goal concerning classroom management. *Classroom management* is the determination of who is supposed to do what in classroom individual and group activities, maintaining order, and employing materials and other resources so that learning and instruction can effectively take place.

> I'm handing out the last page
>
> This way when I'm moving between the rows [the action] students get the chance to ask questions which
>
> They wouldn't dare ask in front of the others
>
> Just because
>
> Because they still don't know each other well they feel uncomfortable (2.1.2)
>
> That's why
>
> I like moving between the desks to explain individually to those who have questions
>
> Specifically about grammar (1.3)

Capitalization on new lines denotes speech continuation after pauses. It was used because the lengthy deliberations had no clear grammatical structure. Ellipses are employed in other examples where parts of the deliberations are omitted. Question marks follow some words to facilitate comprehension. To avoid interpretations, further punctuation was not used (Van Someren, Barnard, and Sandberg 1994).

All schemata in the protocols were coded for greater precision. Repeated schemata were excluded from the analysis. Appendix 2 presents the whole coding system with corresponding examples. The examples were translated from Bulgarian into English by one of the researchers who is proficient in both languages.

Next, the number and size of problem-solving schemata were discerned. *The number of problem-solving schemata* refers to the number of problem-solving schemata per respondent. *The size* is the total number of domain-specific goals and factors in all identified problem-solving schemata per respondent. These were next aggregated for each group and *t*-tests were performed between them to identify if there were significant between-group differences. G1 was compared with G2, G2 with G3, and G3 with G1. Given the small sample size, Cohen's *d* procedure was conducted to establish if the effect size was large enough (i.e. >1) for the procedure to circumvent the probability of Type II error (De Winter 2013).

Regarding the second research question, *constraints* were operationalized as explicit or implicit factors which respondents described as (a) limiting the number of solutions to the problem at hand and (b) permanent throughout the task (i.e. teachers needed to specify them as not having a permanent feasible solution). Additionally, constraints were identified in the schemata where respondents discussed why a solution performed by them was advantageous for achieving the goal compared to at least one other solution (Voss et al. 1983).

The coding of goals, factors, specific knowledge-domain categories, constraints, and strategy comparisons was conducted by two raters. The first rater was the first researcher. The second rater, hired as an independent coder, was a specialist in linguistics and educational studies at university level. She had no knowledge of who the respondents were, their experience group, or the research questions. Interclass correlation procedure was used to determine the interrater reliability on all codes. The reliability was excellent on most codes (i.e. above .900) with the exception of codes regarding subject matter and curriculum issues. Since the disagreement was caused by problems distinguishing between the two in some groups of teachers (see Dimitrova and Kirschner 2020), the codes were conflated. In identifying expert-level schemata, the interrater agreement met the standard 80% threshold (Gatbonton 2008). All

differences were resolved after a discussion. Cases where no agreement was achieved were excluded from the analysis.

4. Results

4.1. Do SL/FL teachers' problem-solving schemata regarding factors and goals differ in teachers with different teaching experience?

Table 1 shows that, on average, G3 teachers recognized more problematic situations and employed more domain-specific knowledge than their G1 and G2 counterparts. Problem-solving knowledge of student motivation was the exception. Also, G3 teachers were more similar in their problem-solving knowledge, whereas G1 and G2 teachers often diverged. For instance, G2 teachers' knowledge of student learning deviated by 5.89 points compared to 8.8 on average per schemata (Table 1).

As shown in Table 2, the *t*-test results aligned with these observations. Except for student motivation, G3 teachers had a significantly greater number of problem-solving schemata which entailed more domain-specific knowledge than G1 teachers did. The differences ranged from $t(8) = 1.94$, $p = .04$, $d = 1.20$ for problem-solving schemata size to $t(8) = 2.71$, $p = .01$, $d = 1.72$ for classroom management. Also, G3 teachers' schemata size, student learning, and classroom management were significantly greater than in G2 teachers, whereby the largest difference concerned knowledge of classroom management with $t(8) = 2.45$, $p = .02$, $d = 1.55$. Finally, G2 teachers did not differ from G1 teachers in any category of problem-solving knowledge (see Table 2).

4.2. Do experienced SL/FL teachers possess expert-level problem-solving schemata? If yes, how does experience affect these schemata?

Three expert-level problem-solving schemata were ascertained in the experienced teachers' groups. A G2 teacher had one, whereas a G3 teacher had two. The G3 teacher had about twice as much

Table 1. Means and standard deviation of size, number, and domain-specific knowledge of problem-solving schemata.

	G1		G2		G3	
	($n = 5$)		($n = 5$)		($n = 5$)	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.
Size of problem-solving schemata	23	16.05	22.2	13.48	40.4	11.97
Number of problem-solving schemata	8.6	5.18	9.6	4.83	15	5.24
Students' learning	8.4	5.18	8.8	5.89	16.6	7.3
Students' motivation	5	6.75	2	2	4.8	5.07
Subject matter/curriculum issues	8.2	4.81	9.4	8.82	14.6	5.41
Classroom management	1.4	1.67	2	1.22	4.4	1.82

Table 2. *T*-statistics and Cohen's *d* of size, number, and domain-specific knowledge of problem-solving Schemata between the groups.

	G1-G2		G2-G3		G1-G3	
Variable	*t*	*d*	*t*	*d*	*t*	*d*
Size of problem-solving schemata	0.09	0.05	2.26*	1.40	1.94*	1.20
Number of problem-solving schemata	0.32	0.20	1.69	1.07	1.94*	1.23
Students' learning	0.11	0.07	1.86*	1.18	2.05*	1.30
Students' motivation	0.95	0.60	1.15	0.73	0.05	0.03
Subject matter and curriculum	0.26	0.16	1.12	0.12	1.97*	1.25
Classroom management	0.65	0.41	2.45*	1.55	2.72*	1.71

Note: $n = 5$ per group.
*$p < .05$, one-tailed test.

teaching experience as the G2 teacher. This indicated a positive effect of professional experience on expert-level schemata number.

Both constraints found in the G3 teacher's schemata were of student motivational nature. The following schema detailing an episode in an English class of lower secondary students is presented here. The factor 'generally they lose focus' formally defined as the students' disengagement from the task was categorized as permanent by the respondent. It was also situated directly at the beginning of the schema.

> They blocked at the end of the class and generally they lose focus
>
> In my opinion they were waiting
>
> For the class to end
>
> And do whatever they had to do later

Next the schema detailed a comparison of two solutions addressing the factor. This comparison discussed the advantages which the game involving irregular verbs has compared with the traditional approach of pen-and-paper exercises. In it, the teacher argued against this approach as '[c]hildren need to know that not everything is get down on your textbook, write [it] down on the board, are you ready, this is correct or incorrect'. She further described this approach as 'useful' but also expressed the realization that it could become 'overly tedious', especially at the end of the class, thus causing the constraint. In contrast, the teacher specified the game as a technique through which she could achieve the goal of

> … *energiz*[ing] *them* [the students]
>
> With the regular verbs past tense past participle
>
> … this [the game] makes them take an interest

Her deliberation also entailed evidence of how effective her solution was. This evidence became obvious from the commentary she made about her failed attempts to make her students answer questions in an orderly manner. She reacted to her own words in the video fragment she was watching with the statement that the students were 'going to shut up because I said so when pigs fly'.

The expert-level problem-solving schema in the protocol of the G2 teacher teaching university-level students of Japanese related to a constraint of curriculum nature. The schema began with an implicit exposition of the constraint, namely no clear relationships between different grammar/vocabulary units or sometimes different uses of the same unit (as in the example) are made in the curriculum.

> … when the same grammar component reappears in one construction then second then third [in the curriculum] with no visible connection between these …
>
> It's very difficult for students to create some
>
> Construction of a system of relationships in their heads while they are indeed related
>
> Here as it was previously in the case of kara [the grammar component]

Then the teacher elaborated on her own approach regarding the constraint:

> I'm taking them to their first academic year [asking them] where did you learn this where did we start why is this so
>
> … and that's my personal opinion and we try to distil this core meaning altogether
>
> … and we don't say that there's one single core meaning in one particular construction sometimes different constructions have several meanings

This solution was contrasted with what the teacher perceived as a standard approach to teaching grammar/vocabulary units among her colleagues. She described it as teaching literal translations of grammar units in Bulgarian or giving instructions to students to 'learn it by heart' since 'this is purely Japanese logic'. She also insisted that the goal for students to create meaningful relationships between grammar units could not be achieved through such an approach (i.e. '[o]verall students find it difficult to create some sort of a system of relationships in their heads') as it does not address the constraint. However, apart from the comment that 'it's easier to work' with students who are familiar with her own approach, the teacher's deliberations provided little evidence of how this approach contributed to her students' achievement. This clearly contrasted with the robust G3 teacher's observations of how students' behaved and performed when certain solutions were applied.

5. Discussion

5.1. Reflections on the findings

The results reveal that the development of SL/FL teachers' informal problem-solving schemata has at least two levels and experience affects these levels differently. The basic level represents the broad knowledge base which the problem-solving process utilizes. It integrates networks of factors, goals, and strategies. The schemata may or may not entail constraints which are essential for recognizing and understanding problems (Marshall 2012). At this level, SL/FL experienced teachers have broader, more comprehensive, and more integrated problem-solving schemata compared to their less experienced counterparts. This is evidenced by the significant differences (a) between the numbers of relationships between goals and factors and (b) the number of goals and factors within these relationships in the least and most experienced teachers. Moreover, all individual categories of domain-specific knowledge, excluding teacher knowledge of student motivation, showed significant growth indicating that with experience teachers develop a significant number of relevant to classroom problems aspects. Such results are hardly surprising given both problem-solving and decision-making share the same broad knowledge base on which problem-solvers identify situations through pattern recognition (Marshall and Seel 2012). Namely, similar to research in general teaching, research in the knowledge differences of ESL/EFL novice and experienced teachers' decision-making and to some extent problem-solving has provided overwhelming evidence supporting the significant knowledge growth in experienced teachers (e.g. Gatbonton 2008; Hogan, Rabinowitz, and Craven 2003; Mackey, Polio, and McDonough 2004; Richards, Li, and Tang 1998; Westerman 1991). The present study suggests similar results regarding the broader group of SL/FL teachers' problem-solving declarative knowledge at this particular level.

On the other hand, the lack of significant differences between G1 and G2 teachers' declarative knowledge agrees with recent findings that teaching experience does not necessarily affect expertise acquisition in a linear fashion (Karimi and Norouzi 2019). In the present study, differences in G1 and G2 teachers' language learning experiences can at least partially explain this phenomenon. While four of G1 teachers studied and have mastered at least one other language (i.e. Bulgarian teachers of less common languages, such as Arabic, take university-entrance examinations in more common languages, such as French), only two G2 teachers had similar learning histories. Research in native ESL teachers suggests that the teachers' language learning experience as learners themselves results in a deeper understanding of the learning processes through which SL/FL learners go through (Ellis 2006). Such knowledge and beliefs likely speed up problem-solving learning through drawing their attention to salient contextual features, as observed in other complex knowledge domains (Bassok and Novick 2012).

Despite the fact that teaching experience appears to be positively correlated with teachers' schemata, only two experienced teachers displayed expert-level schemata. All three schemata at this level entailed knowledge of constraints which helped teachers isolate the causal structure

of barriers to strategies in achieving goals. This manifested itself in their ability to distinguish between important and less important situational factors (cf., Hogan and Rabinowitz 2009). To illustrate this, the expert-level G3 teacher's schema reported here involved the constraint of students' disengagement from task activities, specifying this constraint as a combination of the tediousness of traditional exercises the students were performing and the approaching end of the class. She emphasized the disconnection between these factors and her goal, namely keep students active/energized in their learning. Moreover, similar to social studies experts' schemata (Voss et al. 1983), she compared the effectiveness of her two solutions (i.e. the game and the workbook-based grammar exercises). The G2 teacher exhibited similar knowledge showing that such expert-level problem-solving schemata may occur before the 10th year of teaching experience, not as expected.

These results confirm previous findings in ESL/EFL teaching that apart from broad and interconnected domain-specific knowledge, experts possess knowledge of relevant barriers to achieving learning goals which they employ in creating learning opportunities for students (e.g. Tsui 2009). However, similar to expert mathematics teachers, they also reveal that knowledge of constraints in SL/FL teaching has even deeper implications due to their pivotal role in judging the relative effectiveness of strategies in creating such opportunities (Stigler and Miller 2018). Moreover, the goals in these expert-level schemata were learning goals which reflected theoretically valid rules and principles along the active-constructive line as theorized by Chi (2009). Likewise, the mechanisms supporting the constraints described by these teachers also reflected theoretically valid premises such as causes of lack of on-task behavior (Lee 2014; Stigler and Miller 2018) or the negative effect of linearity in curriculum construction on student learning (Van Merriënboer and Kirschner 2013).

Further, although the effects of experience on the expert-level schemata were less pronounced, they were visible. First, the more experienced G3 teacher had two expert-level schemata, while the less experienced G2 teacher had just one. Second, the G2 teacher expert-level schemata did not involve extensive feedback supporting the effectiveness of her solution, whereas the G3 did. Also, unlike the G2 teacher, the G3 teacher understood the disadvantage of her strategy shown by the rebuttal (i.e. 'they are going to shut up because I said so when pigs fly'). This suggests that the G2's schema was less comprehensive. Although no hard conclusions can be drawn due to the small number of cases, these points suggest that teaching experience positively affects the schema development at this level as well.

On the other hand, these schemata showed clear signs of domain-specific knowledge skewness. While the G3 teacher's constraints concerned student motivational issues, the G2 teacher's concerned cognitive and curriculum-related aspects. This goes counter to the expectation that both motivational and purely cognitive aspects in expert-level schemata would be relevant to achieving learning goals (Chi 2009). In this sense, one can speak of presence of expert-level schemata but not of expert teachers as experts are shown to exhibit all-round domain-specific knowledge of problem-solving (Hogan and Rabinowitz 2009).

5.2. Recommendations for further research

Several other important questions need to be further explored. First, understanding growth in constraint knowledge outside strategy comparative evaluations found in expert-level problem-solving schemata is an important line of research as it may shed more light on SL/FL teachers' expert-level schemata development. Also, a key question that has the potential to reveal why most experienced teachers do not develop expert-level schemata is how misconceptions hinder development of valid causal knowledge (Li and Zou 2017). Another issue which warrants further research is why growth in teachers' problem-solving knowledge of student motivation remains insignificant. At this point, it is difficult to speculate why this is so due to the broad definition employed here and the paucity of research on the issue in SL/FL teaching. Finally, although the study narrowly

focused on experience of GLC teaching, it is highly plausible that other professional experiences also play a significant role in shaping their declarative problem-solving knowledge. Future studies need to consider factors such as regularity of teaching, class sizes, or other tasks (e.g. mentoring, research involvement, tutoring).

5.3. Significance of the study

Although due to its limited sample size, the study cannot be generalized to larger populations, it shows that declarative knowledge acquired with experience has at least two levels. These levels mainly differ by how factors, goals, and strategies are related to each other. At the basic level, these schemata components are related in a linear straightforward fashion. At the expert level, factors create hierarchical networks which are connected with goals and different strategies based on rules and principles of problem-solving and decision-making.

These findings demonstrate that expertise acquisition should be regarded as a multi-level process and theoretically valid rules and principles should be center stage in SL/FL student teachers' formal education. These rules and principles also need to be strengthened in teachers' own practices through deliberation on problematic situations occurring in their classrooms and become the basis of teachers' participation in informal learning activities such as learning in communities of practice. Activities which do not contribute to these elements of teacher knowledge are unlikely to lead to a significant development of expert-level schemata.

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Appendices

Appendix 1.

Group 1: Years of professional experience of teaching general language courses, languages taught, institution of employment, and tertiary education curriculum focus.

Years of professional experience	Language taught	Institution of employment	Educational degree	Tertiary education curriculum focus
0.1	Japanese	School	Bachelor's	Japanese language and cultural studies
1.6	Japanese	School	Bachelor's	Japanese language and cultural studies
2.6	English	School	Master's	English language and literature studies
2.6	Arabic	School	Bachelor's	Arabic language and cultural studies; Teaching Arabic to learners of other languages
1.6	Hindi	University	Bachelor's	Hindi language and cultural studies

Group 2: Years of professional experience of teaching general language courses, languages taught, institution of employment, and tertiary education curriculum focus.

Years of professional experience	Language taught	Institution of employment	Educational degree	Tertiary education curriculum focus
5.5	English	School	Master's	English and Bulgarian language studies; Teaching English and Bulgarian to speakers of other languages
8	English	School	Master's	Primary school education; Teaching English to speakers of other languages
8.4	Chinese	University	Master's	Chinese language and cultural studies
6.9	Japanese	University	Master's	Japanese Language and cultural studies
5	English	School	Bachelor's	Primary school education; Teaching English to speakers of other languages

Group 3: Years of professional experience of teaching general language courses, languages taught, institution of employment, and tertiary education curriculum focus.

Years of professional experience	Languages taught	Institution of employment	Educational degree	Tertiary education curriculum focus
13.5	German	School	Master's	German language and literature studies; Teaching German to speakers of other languages
10	Russian	University	Master's	Russian language and literature studies; Teaching Russian to speakers of other languages
10	Norwegian/ Swedish	University/School	Master's/PhD	Scandinavian languages and literature studies
14.5	English	School	Master's	Primary school education; Teaching English to speakers of other languages
14	Japanese	University	Master's/PhD	Japanese language and cultural studies

Appendix 2. The coding system with examples of goals and factors as domain-specific knowledge categories.

Domain-specific knowledge category	*Goals (1)*	*Factors (2)*
1.1 Students' learning processes, mechanisms, and results	*I'm giving them directions* *So that they don't forget* *To capitalize the first word in the sentence* *As the words there* [on the board] *don't have capital letters* (1.1.1)	*So I'm explaining the structure of the relative clause I'm not explaining it in a great detail because they've already studied many different kinds of subordinate clauses* *And they know the word order which is required* (2.1.1)
1.2 Students' motivation	*I told them already at the beginning that I don't want to disappoint them but the better part of their education will be* [carried out] *on photocopied materials* *Which is not very motivating* *But they are grown mature people* *I hope they'll understand it* (1.1.2)	*We're giving examples here* *They really love giving examples on their own and they give examples and prove themselves* *The good thing about them is there is no infighting in their class when they are giving examples* (2.1.2)
2. Subject matter/ curriculum	*When we started writing … right*? *About the cases when it* [the tense] *is used* *Just in case we wrote down a sentence to illustrate* *What we were saying* *Right*? *… with the goal in mind that at the moment we were saying it* *There is an example* (1.2)	*They worked on lots of things from this student's book last year* [but] *with a different textbook with a different system with a different teacher* *There are parts that are overlapping and others that are additional* (2.2)
3. Classroom management	*Because the goal of this thing* [completing the grammar rules in a designated notebook] *at the end of the school year* *On the final check I put them* [the notebooks] *away* *And I return them when I have to do revision* *It's egotistical of me but it's a workable approach that's how I facilitate my work and the work of the children who cannot find the standard grammar workbooks from the previous school year in the fall* (1.3)	*But there are such* [students] *who still behave like toddlers and I have to deal with them first* *Maybe it's because there are too many students in classes and this slows down the learning process but on the other hand* *There's nothing much to do about it* (2.3)