

LIINA MALVA

Teachers' General Pedagogical
Knowledge: Its Nature, Assessment
and Representation in Practice



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LIST OF ABBREVIATIONS

GPK	general pedagogical knowledge
CK	content knowledge
PCK	pedagogical content knowledge
PKST	Perceptions of Knowledge and Skills in Teaching
TEDS-M	Teacher Education and Development Study in Mathematics
OECD	Organisation for Economic Co-operation and Development
TKS	Teacher Knowledge Survey
ICT	information and communication technology
CFA	confirmatory factor analysis
QAiT	Quality, Appropriateness, Incentive, Time
IRT	Item Response Theory
EAP	Expected <i>A Posteriori</i>
1PL	one-parameter model
ANOVA	Analysis of Variance
TALIS	The Teaching and Learning International Survey
ISCED	International Standard Classification of Education
DIF	differential item functioning
PTMA	point-measure correlation
BA	bachelor's level
MA	master's level

LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following original publications, which are referenced in the text by their Roman numerals:

- I **Malva, L.**, Leijen, Ä., & Baucal, A. (2019). Measuring pre-service teachers' general pedagogical knowledge – What are the results telling? *New Trends and Issues Proceedings on Humanities and Social Sciences*, 6(1), 135–144.
- II **Malva, L.**, Leijen, Ä., & Baucal, A. (2020). Towards Measuring Teachers' General Pedagogical Knowledge – A Mixed Method Investigation of a Pilot Test. *Studies in Educational Evaluation*, 64, 100815.
- III **Malva, L.**, Leijen, Ä., & Arcidiacono, F. (2021). Identifying teachers' general pedagogical knowledge: A video stimulated recall study. *Educational Studies*.
- IV **Malva, L.**, & Leijen, Ä. (2021). Eesti õpetajate, õpetajakoolituse üliõpilaste ning õppejõudude uurimistööalane kirjaoskus. *Eesti Haridusteaduste Ajakiri, Estonian Journal of Education*.

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- Article I:** Participating in the instrument development process, verifying the translation of the instrument, formulating the research questions, carrying out the data collection and analysis, writing the paper as the main author in cooperation with co-authors.
- Article II:** Participating in the development of methodology, participating in the instrument development process, verifying the translation of the instrument, formulating the research questions, carrying out the data collection and analysis, writing the paper as the main author in cooperation with co-authors.
- Article III:** Designing the study, formulating the research questions, developing the instruments, carrying out the data collection and analysis, writing the paper as the main author in cooperation with co-authors.
- Article IV:** Designing the study, formulating the research questions, developing the instruments, carrying out the data collection and analysis, writing the paper as the main author in cooperation with co-authors.

1. INTRODUCTION

Teachers' knowledge plays an important role in instructional quality and is reflected in students' learning outcomes (Grossman & McDonald, 2008). Consequently, the importance of supporting pre-service and in-service teachers' knowledge development has been emphasized repeatedly by teacher education researchers. Three components of teachers' knowledge are commonly differentiated: content knowledge (knowledge of the subject), pedagogical content knowledge (knowledge about teaching and learning a specific subject) and general pedagogical knowledge (knowledge about teaching and learning that is not linked to subject matter) (Baumert et al., 2010; König & Pflanzl, 2016; Shulman, 1986). Although several empirical studies have focused on content knowledge and pedagogical content knowledge, teachers' general pedagogical knowledge (GPK) is less commonly studied (König, Blömeke, Paine, Schmidt, & Hsieh, 2011).

Based on Shulman (1987), GPK has been described as consisting of "broad principles and strategies of classroom management and organization that appear to transcend subject matter" (p 8). However, despite having the term *general pedagogical knowledge* available for decades, researchers still claim that it is used differently in different countries. More specifically, the definition and content of GPK tends to be influenced by the educational systems in different cultural contexts. Consequently, researchers do not agree on what exactly constitutes teachers' GPK and how to define it (König et al., 2011).

While research in the last decades has indicated that teachers' professional development and knowledge is an important factor in effective teaching and ensuring better learning outcomes for students (Baumert et al., 2010), the need to assess teachers' GPK, together with challenges in the development process of instruments for assessment, has also been continuously highlighted (e.g., König et al., 2020). Developing valid empirical instruments provides an opportunity to discover how GPK is connected to other teaching-related variables and thereby generates necessary information for teacher education research and teacher education, including continuing education programs for in-service teachers. Despite this, developing instruments for empirical measuring of GPK is a rather new direction and has only been tackled by a few researchers during the last decade (e.g., Depaepe & König, 2018). Therefore, the focus of the current thesis is on the nature and assessment of teachers' GPK.

1.1 Focus of the research

This doctoral thesis is based on two studies. Study I focuses on an instrument developed for measuring teachers' GPK, investigating its overall quality and applicability to different teaching-related sample groups. Study II explores GPK in the context of practical teaching, describing the application of GPK dimensions

from Study I in the everyday teaching context and exploring the possible connections between the dimensions of GPK, as suggested by Study I.

In order to address the abovementioned issues, **the aim** of the doctoral thesis is to investigate a newly developed instrument for assessing teachers' GPK and to gain more insight into the dimensions of GPK that teachers use in everyday teaching practice. Based on this aim, the following **research questions** were established:

1. What is the quality of the initial GPK test instrument and its items in the Estonian context?
2. What are the differences between the GPK of Estonian pre-service teachers, in-service teachers and teacher educators, and which background variables are related to the differences in their knowledge level?
3. Which dimensions of GPK do Estonian teachers use in everyday teaching practice, and how are these dimensions connected?

The research questions have been addressed in the following original publications:

Articles I and II address research questions 1 and 2 by investigating the newly developed instrument and interpreting the results in detail. While **Article I** addresses part of one sample group (pre-service teachers at the University of Tartu) and discusses their test results, and **Article II** includes the full dataset and focuses mostly on the quality of the instrument. **Articles I and II** are based on Study I of the thesis.

Articles III and IV address research question 3 and explore the concept of GPK in the context of everyday teaching, using the theoretical framework of the instrument from **Articles I and II**. While **Article III** gives a complete overview of the dimensions of GPK used in everyday teaching, **Article IV** focuses merely on one GPK dimension (research literacy) due to its variation between the instrument framework and teachers' interpretations in practical teaching. **Article III** is based on Study II, and **Article IV** is based on Study I and Study II of this thesis.

2. THEORETICAL BACKGROUND

The following sections will give an overview of the relevant theoretical literature regarding teachers' knowledge and the development of research in this area. Then, the conceptualisation of teachers' knowledge will be introduced, followed by a more detailed overview of GPK as a focus of this study. Finally, recent developments in the field of measuring teachers' GPK are provided.

2.1 Teachers' knowledge

In the 1980s, a "cognitive change" emerged in teacher research. Instead of only focusing on practical actions and skills of teachers, more attention began to be paid to the cognition of teachers (Clark & Peterson, 1986), and teacher research started to propose teaching as a profession that possesses a specialized knowledge base (Shulman & Sykes, 1986; Shulman, Sykes, & Phillips, 1983; Shulman, 1986, 1987). Teachers were expected to think deeply about what they did in the classroom and why in order to better understand their previous and current activities (Richert, 1990). It was also noted that it is possible to distinguish and define the formal knowledge of teachers, which supports practical actions, alongside common wisdom (Gardner, 1989). With the teacher research shift to cognition and action, the importance of focusing on teachers' knowledge in certain situations was emphasized by several authors (Brown, Collins, & Duguid, 1989; Leinhardt, 1988). In 2000, Putnam and Borko stated that teachers as professionals are expected to be up to date on recent research to find the most effective ways of teaching to support their students in developing deeper understanding while ensuring their learning experience by providing meaningful context for subject matter. This means that teachers are expected to use their abstract knowledge in practice while keeping a connection with recent empirical studies (Simons & Ruijters, 2014). Formal knowledge that is mainly based on scientific results, as opposed to the wisdom of intuition, defines teachers' professionalism (Gardner & Shulman, 2005).

Since the change described above, a large amount of research has been carried out to discover the connections between teachers' thoughts and actions (see e.g., Glogger-Frey, Herppich, & Seidel, 2018; Marcos & Tillema, 2006). Knowledge related to teachers' activities has also been defined as teachers' practical knowledge (Connelly & Clandinin, 1988, 1990; Zantig, Verloop, Vermunt, & Van Driel, 1998). In addition to cognition, practical knowledge also includes beliefs and values. Teachers' practical knowledge has been described as action-oriented, person- and context-bound, and implicit and tacit, while integrating formal knowledge from teacher education and informal knowledge from everyday practice with values and beliefs (Van Driel, Beijaard, & Verloop, 2001). Therefore, researchers have emphasized that it is important to understand knowledge in the context of teachers' action, as this is the core of their professionalism

(Ross & Chan, 2016), and there is a specific kind of knowledge that is shared among practicing teachers (Meijer, Verloop, & Beijaard, 2002). Shalem (2014) divided teachers' knowledge into theoretical knowledge (describing knowledge from educational theories) and working knowledge (describing knowledge from contextually specific experiences). In addition to theoretical and conceptual knowledge, up-to-date teacher education programs take practical knowledge into account and aim to support the development of teachers' practical knowledge while connecting it to research-based knowledge (Meijer, 2013). As teachers' practical knowledge is an important addition to the existing theories, it is inevitable that teachers' knowledge in general should be studied in the context of practical teaching.

From the teacher education side, universities have an important role and responsibility to provide pre-service and in-service teachers with updated knowledge that is necessary for their work. In line with research, teacher education programs have started to pay more attention to teachers' knowledge. Teachers' practical knowledge is seen as a relevant addition to already well-known theories, which is why contemporary teacher education purposefully offers more opportunities to link practical knowledge with research-generated knowledge (Meijer, 2013). However, despite the attempts to connect more theory and practice, teacher educators are always challenged with offering high-quality and updated education in terms of teachers' knowledge (Hammerness, 2013; König, 2013; Korthagen, Kessels, Koster, Lagerwerf, & Wubbels, 2001). Understanding teachers' practical knowledge leads researchers to further investigate the situations in which teachers' knowledge is used (Ross & Chan, 2016).

2.2 Domains of teachers' knowledge

The "cognitive change" in teacher research in the 1980s brought forward a discussion on the domains of teacher knowledge that serve as the core of their profession. The main impetus for this was a gap in teacher research, namely a gap between teachers' understanding of the subject content and the instructions provided to students (Shulman, 1986). Therefore, in earlier research, more attention was paid to teachers' knowledge related to the content. For example, this content-related knowledge could include subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. The first, content-focused domain focuses merely on the subject itself, organizing the knowledge of the discipline. The second category, pedagogical content knowledge, connects knowledge of a subject with pedagogy – the best ways to represent ideas from the discipline. The third category, curricular knowledge, refers to programs designed for teaching in schools, again focusing on particular subjects. In 1987, Shulman published a organisation of teachers' knowledge that set content knowledge as equal with other categories: 1) content knowledge (CK); 2) general pedagogical knowledge (GPK); 3) curriculum knowledge; 4) pedagogical content knowledge (PCK); 5) knowledge of learners and their characteristics; 6) knowledge of educational

contexts; and 7) knowledge of educational ends, purposes, and values. Even though Shulman and his research group kept their main focus on CK and PCK, they did start integrating content into other categories of knowledge (Wilson, Shulman, & Richert, 1987). This integration allowed teacher researchers to pay more attention to teachers' practical wisdom and, more specifically, to how teachers can transform their knowledge into classroom instruction (Cochran-Smith & Lytle, 1999).

In parallel with Shulman's attempts, other researchers also started to expand their exploration of teachers' knowledge from a focus on content knowledge. In 1990, Grossman proposed a division of four areas important for teachers' professional knowledge and emphasized interactions between them: 1) GPK; 2) subject matter knowledge; 3) PCK; and 4) knowledge of context (community, school district, school, and students). Almost a decade later, Darling-Hammond (1999) conducted a literature review, analysing studies carried out on different knowledge areas in teacher preparation. The results of the review showed that there is more evidence on teacher effectiveness in terms of teachers' knowledge about teaching and learning, as opposed to subject-matter knowledge for which the impact is less. This also shows that more research started to focus on the three core domains of teachers' knowledge evolving from Shulman's (1987) initial categories: GPK, PCK, and CK. As indicated in a review conducted by Bukova-Güzel (2010) and work by König et al. (2016), GPK and CK are inputs for PCK, as PCK includes both knowledge of content and knowledge about teaching students (Figure 1). In other words, teachers need to be able to make content understandable to students (Niemelä & Tirri, 2018). Grossman's (1990) division into four areas suggests that knowledge of context is a separate domain; however, research in this area has provided no evidence for this fourth division.

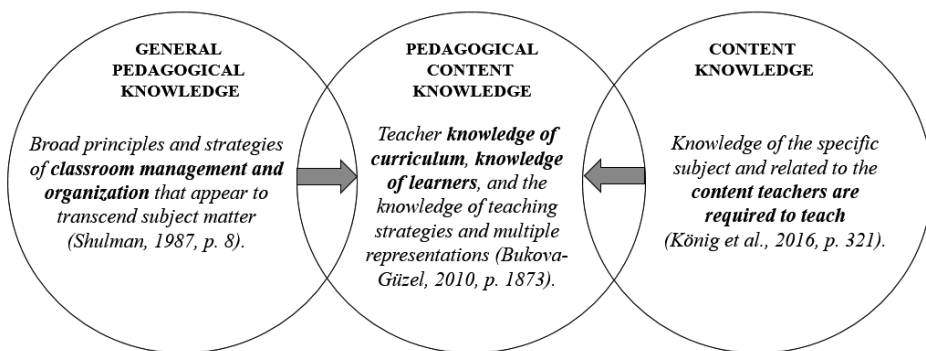


Figure 1. Definitions and connections between GPK, PCK, and CK.

Despite the existing consensus on the three domains of teachers' knowledge among researchers (Lohse-Bossenz, Kunina-Habenicht, Dicke, Leutner, & Kunter, 2015), the interrelations between the domains and their joint importance in teaching still lacks empirical evidence. In Estonia, which is the context of the current thesis, mainly PCK has been previously studied (e.g., Luik, Taimalu, &

Suviste, 2018; Luik, Taimalu, & Laane, 2019). As CK and PCK have been in the centre of teacher research since the 1980s, the scarcity of evidence might have been caused by the lack of studies focusing on GPK itself.

2.3 The nature of teachers' general pedagogical knowledge (GPK)

According to the initial definition proposed by Shulman (1987), teachers' general pedagogical knowledge presents "broad principles and strategies of classroom management and organization that appear to transcend subject matter" (p. 8). Since then, the term has been elaborated by several researchers; however, a common understanding is still missing. König et al. (2011) have pointed out that the term is often influenced by different educational systems as well as cultural perspectives of education. Therefore, it is necessary to describe and synthesize the different characteristics used for GPK. Typically, a definition of GPK is provided in research papers, concluding the overall meaning of the concept itself. Then, the detailed and systematized content of GPK is usually presented (here and hereafter referred to as the dimensions of GPK). Next, an overview of different versions of GPK definitions is given, followed by a description of the dimensions used in empirical research.

2.3.1 Definitions of GPK

As expected, the majority of definitions provided by different authors are based on Shulman's (1987) initial definition. König and his co-authors, who have carried out several studies on GPK, added several dimensions to the initial definition: knowledge of learners and learning, assessment, and educational contexts and purposes (e.g., König et al., 2011). Also, other authors have moved forward from being limited to classroom management, as was initially proposed by Shulman (1987). Großschedl, Harms and Kleickmann (2015) and Lauermaun and König (2016) brought in learners' motivation. Happonen and Määtä (2011), who did not rely on Shulman's work, emphasized supportive interactions with children and the principles of development with the aim to support students' learning.

In addition to defining GPK through learning and learners, the teaching process itself has gained more attention in the last decade. Lauermaun and König (2016), who intended to combine different definitions, added aspects of lesson planning and differentiated instruction. Choy, Wong and Lim (2013) defined GPK as instructional methods, activities and assessment. On the other hand, knowledge of curriculum, which is related to teaching, is not a common feature represented in GPK definitions. Instead, only Hudson (2004) has mentioned it, although it was mainly in the context of science teaching. This shows that knowledge of curriculum is strongly tied to the subject itself and therefore ignores one of the most vital aspects of defining GPK: transcendence over subject matter

(Shulman, 1987). Atjonen, Korkeakoski and Mehtalainen (2011) also mention educational goals, values, and purposes, regardless of the subject. In one of the latest attempts, Guerriero (2017) has defined teachers' GPK as "the specialised knowledge of teachers in creating and facilitating effective teaching and learning environments for all students, independent of subject matter" (p. 80).

In synthesizing the expansion of the GPK definition over the decades, it can be concluded that it consists of three common components that are recurrent in the works of different authors. Firstly, GPK is understood to be subject-transcendent, meaning that it is an important knowledge domain for any teaching area. Secondly, it covers knowledge about instructional processes; more specifically, these are learning and teaching processes, classroom management, and educational context. And thirdly, it accounts for goals related to the learner, such as supporting students' development and motivation. The broad nature of the synthesized definition shows how it has been elaborated over the years since the first definition proposed by Shulman (1987).

2.3.2 Dimensions of GPK

The dimensions of GPK present a comprehensive structure of the knowledge domain. Several attempts have been made by researchers to investigate these. As expected, studies carried out in the 1990s instead focus on finding the dimensions through qualitative data and propose an initial structure. More recently, researchers have tested the proposed dimensions in quantitative studies, supplementing previous findings. During the last decade, the Perceptions of Knowledge and Skills in Teaching (PKST; e.g., Choy, Lim, Chong, & Wong, 2012) survey instrument has appeared in several publications in which the GPK dimensions are divided as follows: 1) student learning; 2) lesson planning; 3) instructional support; 4) accommodating diversity; 5) classroom management; and 6) care and concern. More recently, the TEDS-M (Teacher Education and Development Study in Mathematics; e.g., König et al., 2011) test was developed, validated and used to assess teachers' GPK in numerous studies. The dimensions of GPK in the TEDS-M test have been divided as follows: 1) structure (lesson planning and objectives); 2) motivation/classroom management; 3) adaptivity (differentiation, teaching methods); 4) assessment. Despite several studies carried out with the TEDS-M instrument, Guerriero (2017) has stated that the evidence on GPK is still rather scarce. Therefore, the OECD (Organisation for Economic Co-operation and Development) elaborated the TEDS-M test and developed a GPK framework with three main and six sub-dimensions, which resulted in the Teacher Knowledge Survey (TKS; Sonmark, Revai, Gottschalk, Deligiannidi, & Burns, 2017) test instrument. As this thesis focuses on the TKS instrument, the six sub-dimensions according to the TKS framework will be described next and supported with previous research on GPK in which the researchers have considered similar dimensions. This is followed by a description of dimensions in addition to those covered by TKS that were found in other studies and an assessment of novel aspects of the TKS that had not been

previously addressed. An overview of the dimensions in the TKS instrument as well as other GPK-related studies is presented in Table 1.

The dimension of *teaching methods and lesson planning* considers the effective use of instructional time while facilitating various teaching methods (Trinidad-Velasco & Reyes-Cardenas, 2017; Voss, Kunter, & Baumert, 2011). Choy et al. (2013) have described lesson planning as part of pedagogical reasoning in order to explain what and why teachers plan to do. That is why a big part of lesson planning is theoretical knowledge about appropriate learning opportunities and possibilities for children (Happo & Määttä, 2011). The practical side of the dimension of lesson planning comes out when a teacher defines learning objectives and starts to structure the lesson, together with choosing suitable teaching methods (Choy et al., 2013; Hudson, 2004, 2007; Hudson, English, & Dawes, 2015; König, 2013; Torff & Sessions, 2005). Knowledge of planning should also include the complexity of the learning environment (Choy et al., 2013) and students' different abilities (Choy et al., 2012; Wong, Chong, & Choy, 2008). In addition to planning, this dimension also includes considering teaching methods. Several studies have used the term *instructional strategies* to describe the role of teaching methods (e.g., Mullock, 2006). In the phase of preparation, knowledge of instructional strategies is applied when selecting appropriate modes to support instruction (e.g., materials), planning the use of ICT (information and communication technology) and designing the assessment tools (Choy et al., 2012, 2013). Großschedl et al. (2015) have put more emphasis on the lesson itself, stating that instructional strategies cover knowledge of teaching methods and how to use them during the lesson. Gathbonton (1999, 2008), on the other hand, describes instructional strategies as the flow of the lesson: procedures, activities, time management, and so on. She also emphasizes the importance of knowing the appropriate activities

Classroom management focuses more on classroom activities and managing events during a lesson, including keeping a good pace, giving clear instructions and supporting students' attention (Voss et al., 2011). Another major theme in this dimension is dealing with behavioural issues, as well as getting students' attention for academic engagement – both of which form the basis of effective learning (Capel, Hayes, Katene, & Velija, 2009; Trinidad-Velasco & Reyes-Cardenas, 2017). Teachers should know how to create a safe environment that supports focused thinking and learning (Choy et al., 2013). This includes preventing any disruptions that might occur (e.g., Blömeke, Busse, Kaiser, König, & Suhl, 2016) and knowing strategies for monitoring and supporting students' behaviour while keeping the overall discipline in order to maintain the flow of the lesson (Choy et al., 2012, 2013; Hudson, 2004; Wong et al., 2008). In addition, applying appropriate classroom management strategies (Choy et al., 2012) should go together with supporting students' attention to stay focused on the academic content (Torff & Sessions, 2005). A prerequisite for supporting students' attention is to have a good relationship with the group as a whole (Torff & Sessions, 2005; Wong et al., 2008) and make contact with every student (Gathbonton, 1999; Mullock, 2006).

Learning and development mostly revolves around cognitive learning processes, for example, memory, prior knowledge, information processing, and student engagement (Trinidad-Velasco & Reyes-Cardenas, 2017; Voss et al., 2011). Liakopoulou (2011) has asserted the importance of being aware of cognitive development stages. Choy et al. (2012) place greater emphasis on the role of supporting students' interest both in content and academic engagement, while Capel et al. (2009) have emphasized the relevance of being aware of individual students. Therefore, knowledge of learning and development has an important role in understanding diversity and differences among students – knowing how to evaluate their learning and assist them during the process according to their own pace (Choy et al., 2012; Wong et al., 2008).

Affective-motivational dispositions take into account knowledge about the role of motivation in achievement as well as motivational strategies for the whole group or individual student (Voss et al., 2011). Großschedl et al. (2015) point out the importance of motivation in the learning process and assert that teachers should gain knowledge on how to keep students motivated on academic tasks while supporting achievement, how to prevent a lack of motivation, and how to support motivation through settled routines (e.g., König, 2013).

Evaluation and diagnosis procedures consider formative and summative assessments and which type of assessment to use for different purposes while supporting student motivation and maintaining the quality of assessment (Trinidad-Velasco & Reyes-Cardenas, 2017; Voss et al., 2011; Wong et al., 2008). Assessment appears in different stages of teaching (Hudson, 2004, 2007; Hudson et al., 2015) and requires knowledge about students' achievement and evaluation principles (König et al., 2016). In order to carry out a reliable and valid assessment, teachers must know about assessment types and how they function, criteria for evaluation, and the effects of a teacher's own expectations (König, 2013; König & Pflanzl, 2016). König et al. (2014) have asserted that assessment is a central part of general pedagogy and plays an especially important role in addressing individual students' needs in the planning phase.

The literature reveals one element that is not distinguished in the TKS as a separate dimension: *students' diversity*. In the previous studies, students' diversity is approached as multiculturalism (Capel et al., 2009; Liakopoulou, 2011), special needs (Capel et al., 2009; Choy et al., 2012; Liakopoulou, 2011), and individuality and differentiation (Capel et al., 2009; Happo & Määttä, 2011). A common characteristic between studies is to work with heterogeneous groups and provide adaptivity in terms of differentiation while using a variety of teaching methods (Blömeke et al., 2016; König, 2013; König et al., 2014, 2011, 2016; König & Pflanzl, 2016; König & Rothland, 2012). These studies have specified that working with students' diversity means having knowledge about accommodations in learning pace and the support a student needs. When comparing the literature about the students' diversity dimension with the TKS dimensions, it can be assumed that in the TKS, topics related to students' diversity are considered throughout other dimensions (Sonmark et al., 2017). For example, under the dimension of *teaching methods and lesson planning*,

knowing when and how to apply various teaching methods is considered to be a part of the GPK. In addition, the *learning and development* sub-dimension emphasizes fostering individual learning, and the sub-dimension of *affective-motivational dispositions* expects knowledge on how to motivate a single student as well as the whole group. This shows how, in the latest research, knowledge about students' diversity is not considered to be something different or separate, but rather as a coherent part of the overall GPK.

Table 1. Dimensions of GPK used in the TKS instrument and in other GPK-related studies.

OECD TKS		Other publications	Authors/Instruments
Dimension	Sub-dimension		
Instructional process	Teaching methods and lesson planning	Lesson planning	Hudson, 2004, 2007; Torff & Sessions, 2005; Wong et al., 2008; Haplo & Määttä, 2011; Voss et al., 2011; Hudson et al., 2015; Trinidad-Velasco & Reyes-Cardenas, 2017*; PKST; TEDS-M
		Instructional strategies	Gatbonton, 1999*, 2008; Torff & Sessions, 2005; Mullock, 2006*; Voss et al., 2011; Großschedl, Harms, & Kleickmann, 2015; Trinidad-Velasco & Reyes-Cardenas, 2017*; PKST
	Classroom management	Classroom management	Gatbonton, 1999*; Hudson, 2004; Torff & Sessions, 2005; Mullock, 2006*; Capel et al., 2009; Voss et al., 2011; Wong et al., 2008; Trinidad-Velasco & Reyes-Cardenas, 2017*; PKST; TEDS-M
Learning process	Learning and development	General learning processes	Wong et al., 2008; Capel et al., 2009; Liakopoulou, 2011; Voss et al., 2011; Großschedl et al., 2015; Trinidad-Velasco & Reyes-Cardenas, 2017*; PKST; TEDS-M
	Affective-motivational dispositions		
Assessment	Evaluation and diagnosis procedures	Assessment	Hudson, 2004, 2007; Wong et al., 2008; Voss et al., 2011; Hudson et al., 2015; Trinidad-Velasco & Reyes-Cardenas, 2017*; TEDS-M
	Data and research literacy	—	Sonmark et al., 2017
—	—	Students' diversity	Capel et al. 2009*; Liakopoulou 2011; Haplo & Määttä, 2011; PKST; TEDS-M

* studies that found dimensions of GPK through qualitative research.

Finally, the TKS has a dimension of *data and research literacy*, which has not appeared in any of the previous studies. Sonmark et al. (2017) describe this dimension as knowledge of statistical concepts and how to interpret and use research results in teaching practice in order to support students' learning process. It also emphasizes teachers' knowledge on how to collect data about their own students and adapt their practice according to the results. Data and research literacy can also be closely linked to assessment; however, it is still a novel dimension distinguished in teachers' GPK.

2.4 Measuring teachers' GPK

In the few attempts to measure GPK carried out during the last two decades, two types of measurements have been used: 1) a survey in which teachers indicate their level of knowledge on a certain scale; and 2) a test instrument that uses questions to assess knowledge. Among the former, the PKST survey has been developed and used in several studies, while in the case of the latter, TEDS-M is the most common test. In the following section, a short overview is given about the background and content of these two instruments, and some example studies using these instruments are provided.

In 2008, Wong et al. published a paper introducing a survey for assessing pedagogical knowledge. The survey consisted of 34 questions, and the respondents had to mark their perception of their own pedagogical knowledge level on a 5-point Likert scale (from 1 as "no knowledge at all" to 5 as "highly knowledgeable"). Data from 596 participants was used to run a factor analysis (principal components extraction with Varimax rotation) which resulted in five factors: 1) facilitation; 2) assessment; 3) management; 4) preparation; and 5) care and concern. Finally, each factor consisted of five or six items, and a total of five items were removed due to not fitting the data. The factors showed either good or excellent reliability, with Cronbach's alpha varying from .77 to .89. The paper did not describe the development process of the instrument or the theoretical framework behind it. However, in 2012, Choy et al. published a study that cited Wong et al. (2008) as "an earlier data set to obtain some initial insights into dimensionality of the PKST" (p. 590). In Choy et al. (2012), the background of the instrument is explained. The initial aim was to develop an instrument to collect information on teacher education programs at the National Institute of Education, Singapore. To do so, the research team first conducted a thorough review of literature and then, during the item development, consulted different professionals and policymakers in the area of teacher education. Choy et al. (2012) collected data from 323 pre-service teachers and carried out confirmatory factor analysis (CFA) to establish the construct validity for the PKST instrument. The model resulted in 38 items organized among six factors: 1) student learning; 2) lesson planning; 3) instructional support; 4) accommodating diversity; 5) classroom management; and 6) care and concern. Cronbach alpha reliability for the different factors was good, varying from .71 to .83.

The PKST instrument is mostly used in longitudinal studies to investigate pre-service teachers' pedagogical knowledge at the start of and graduation from a teacher education program, as well as during the first years of employment. Therefore, the main aim has been to monitor any changes in knowledge over the years and use that information for program development. For example, Choy et al. (2013) published a paper investigating beginning teachers' pedagogical knowledge at their graduation from a teacher education program and at the end of their first and third years of working as a teacher. The authors used three factors from the PKST that are directly related to teaching: 1) lesson planning; 2) classroom management; and 3) instructional strategies (altogether 18 items). The results from 358 respondents showed that the beginning teachers' pedagogical knowledge did increase significantly over the three time points of measurement. More specifically, by the end of the first year of teaching, only their perceptions of classroom management knowledge had a significant increase. The authors explain that growth in one factor might be because of professional development courses that are provided for novice teachers. However, over three years, other factors also demonstrated a significant increase, showing a continuation in the growth of pedagogical knowledge after graduating from teacher education and beginning a teaching career.

In their discussion, Choy et al. (2013) demonstrate the disadvantage of using self-reported survey instruments – the actual teaching practices are not investigated. Another limit of such instruments is that the answers reflect respondents' self-perception. To address the latter issue, one option is to develop tests that assess teachers' GPK. In 2011, König et al. published a study that assessed pre-service teachers' professional knowledge, including GPK. The theoretical framework was based on the QAIT model (Quality, Appropriateness, Incentive, Time), designed to describe effective instruction (Slavin, 1994). In addition, during test development, the researchers were looking at literature on teaching quality in terms of didactics. This, together with the QAIT, resulted in defining four dimensions of GPK: 1) structure; 2) motivation/classroom management; 3) adaptivity; and 4) assessment. 77 items were developed to assess GPK in the TEDS-M test. To check the dimensionality and reliability, the authors used Item Response Theory (IRT). The results revealed that the four-dimensional model has lower reliability scores (.64 to .72) than the one-dimensional model (.78). Nevertheless, the researchers decided to use the four dimensions separately as they were not highly correlated.

From there on, the TEDS-M test has been repeatedly used to find evidence of the level of teachers' GPK. For example, a shorter version of TEDS-M was used by König and Rothland (2012) to investigate pre-service teachers' (n=1287) GPK in relation to their teaching motivation. The results showed that motivation and GPK are not very closely connected. König (2013), however, found with the TEDS-M test that pre-service teachers' (n=522) GPK increases throughout their teacher education program. In this study, the one-dimensional model again presented a good EAP (*Expected A Posteriori*) reliability of .86. After this, another study looked at the relationship between GPK and noticing and inter-

preparing classroom situations (König et al., 2014). Longitudinal data from 171 in-service mathematics teachers showed that only interpreting correlates with GPK. In addition, more evidence was provided on the continuous growth of GPK among in-service teachers. Nevertheless, the authors point out a limitation of the study – data was collected only from mathematics teachers, and therefore, we should be careful with generalizing its results. Another subject-centred study was carried out by König et al. (2016) when pre-service teachers' professional knowledge was assessed among teachers who teach English as a foreign language. In that study, GPK was targeted together with PCK and CK. The results showed that both GPK and CK are closely connected to PCK; however, the three-dimensional model for CK, PCK and GPK is stronger than the one-dimensional model for professional knowledge. GPK being closely related to PCK was expected, as PCK relies heavily on pedagogical concepts. The authors argue, based on their results, that GPK should not be ignored, as it is an important source for research. König and Pflanzl (2016) also found evidence for teachers' GPK being positively correlated with students' perceptions of instructional quality. In 2016, König and Kramer compared a pen-and-paper TEDS-M test with a video-based measurement of classroom management expertise. They found that expertise in classroom management and GPK are positively correlated; however, they can still be empirically separated. Also, in the same study, they concluded that classroom management expertise predicts instructional quality of classroom management better than GPK. Depaepe and König (2018) found that there was no relationship between GPK and teachers' self-efficacy beliefs and that, with the TEDS-M test, it is only possible to predict instructional practices that relate to student support and lesson structure. The TEDS-M has also been used to show how teacher education learning opportunities have an impact on GPK (Klemenz, König, & Schaper, 2019). In 2020, König et al. explored how GPK predicts situation-specific skills of adaptivity in lesson planning for pre-service teachers.

In conclusion, GPK is a complex knowledge domain that is related to numerous teaching-related variables, as shown in empirical works carried out with the TEDS-M instrument. Based on previous studies, GPK increases during teacher education and keeps improving during the in-service teachers' practice (König, 2013), while teacher education learning opportunities affect the growth of GPK (Klemenz et al., 2019). In addition, GPK is found to be positively correlated with instructional quality (König & Pflanzl, 2016) and classroom management expertise (König & Kramer, 2016). These studies carried out with the TEDS-M instrument indicate that when teachers are provided with more learning opportunities and as they advance in teacher education, GPK improves and they become more skilful and effective in classroom practice.

3. RESEARCH METHODOLOGY

In this section, an overview of the research methodology of the dissertation is presented. First, the research design of the two studies is introduced. Next, the context of the studies is described, with the aim of providing contextual information about Estonian teachers and teacher education. Thereupon, the sample, data collection together with instruments, and applied data analysis methods are explained separately for the two studies. A summarized overview of the research methods used to address the research questions of the thesis is presented in Table 2.

3.1 Research design

The research in the current dissertation was carried out in two studies: the first investigated teachers' GPK and assessed the test instrument, and the second consisted of a video-stimulated recall interview about GPK used in practice. Study I was largely quantitative; however, in order to gain more insight into the test instrument, a qualitative approach was added when analysing the content of test items. Study II was entirely qualitative, relying on the same framework as was used in the data collection instrument of Study I. Therefore, the dissertation is described as having a cross-sectional mixed-methods design, combining both quantitative and qualitative methods in order to provide conclusions that supplement each other while benefiting from the strengths of both methods (Ivankova, Creswell, & Stick, 2006).

The aim of Study I was to pilot a TKS instrument for investigating teachers' GPK and assess the test instrument in terms of its dimensionality, difficulty and applicability in measuring different sample groups. Study I relied on an initial GPK definition proposed by Shulman (1987) and an extended version proposed by Guerriero (2017). The empirical part was developed based on the already validated instrument TEDS-M (see e.g., König et al., 2011). The instrument development and data collection in Study I was part of an international large-scale study carried out by the OECD; however, the data here focuses on an Estonian case, as the educational context can be culture sensitive. The results of Study I are presented in Articles I, II and IV.

The aim of Study II was to gain more insight into teachers' GPK used in practical teaching and to validate the proposed GPK framework in the context of everyday teaching. Due to the complexity of teachers' GPK, it is important to study it in different contexts and using a variety of data collection methods. Due to the very theoretical nature of GPK, as seen in Study I, it was necessary to find out which GPK dimensions teachers use in their everyday teaching work.

Table 2. A summarized overview of the research methods addressing the research questions of the thesis.

Research question	Study	Participants	Data collection instrument	Collected data	Data analysis	Articles
RQ1: What is the quality of the initial GPK test instrument and its items in an Estonian context?	Study I	Sample I: 170 pre-service teachers 175 in-service teachers 48 teacher educators	Teacher Knowledge Survey (Sonmark et al., 2017)	Test scores	<u>Quantitative data analysis:</u> IPL Item Response Theory (Rasch measurement) <u>Qualitative data analysis:</u> inductive text analysis of test items	Article II
RQ2: What are the differences between Estonian pre-service teachers', in-service teachers' and teacher educators' GPK, and which background variables are related to the differences in their knowledge level?	Study I	Sample I: 170 pre-service teachers 175 in-service teachers 48 teacher educators	Teacher Knowledge Survey (Sonmark et al., 2017)	Test scores	<u>Quantitative data analysis:</u> IPL Item Response Theory ANOVA Hierarchical linear regression	Article I Article II Article IV
RQ3: Which dimensions of GPK do Estonian teachers use in everyday teaching practice, and how are these dimensions connected?	Study II	Sample II: 7 in-service teachers	Video-stimulated recall interview (semi-structured)	Video recordings of classroom practice, observation protocols, interviews	<u>Qualitative data analysis:</u> deductive and inductive content analysis	Article III Article IV

In addition, as the results of Study I implied that GPK was unidimensional, this was also investigated further in Study II. Study II was carried out as qualitative research with the aim to further explore the nature of GPK and provide supplementary information to Study I, as the qualitative methodology allows subjects to relive situations and recall thoughts that are not limited to the rigid structure of a data collection instrument (Rowe, 2009; Sugrue & Day, 2002). The results of Study II are presented in Article III and Article IV.

3.2 Research context

In the following section, the context of the research is described in more detail, focusing on Estonian in-service teachers and also teacher education, which includes both pre-service teachers and teacher educators. The aim of the context description is to provide background information and allow possible transferability between contexts.

3.2.1 Estonian teacher education

Two universities provide teacher education programmes in Estonia. Depending on the curriculum, teacher education is mostly offered at the master's level. The only exceptions are pre-school teachers and vocational teachers, who can already enter a teaching job after earning a bachelor's degree. While primary school teachers and special education teachers have to pass both the bachelor's and master's level, subject teachers (e.g., mathematics teachers) enter teacher education only at the master's level. Before that, subject teachers complete a subject-specific curriculum (e.g., mathematics). Teacher education at the bachelor's level lasts for 3 years and 2 years at the master's level.

The curricula of teacher education follow a similar structure, containing modules of general pedagogy, subject-specific teaching, and pedagogical internship. Teacher education finishes with a written thesis. In recent years, the organization of internships has been changing, allowing pre-service teachers to already get acquainted with the school environment in their first semester. The observations and practice lessons carried out in schools are analysed in university courses through reflective writing and group discussions. All students have mentors both from a school and their university (Leijen & Pedaste, 2018).

The teacher educators carrying out university courses and leading the curricula may have different backgrounds; however, a doctoral degree is encouraged. Teacher educators come from different educational or education-related disciplines, for example, from psychology. The proportion of teaching and research can vary depending on the exact position. Nevertheless, teacher educators are encouraged to undertake and are included in many research projects. The quality of teaching at the university is mainly evaluated based on teacher educators' self-evaluation and pre-service teachers' feedback. Professional development courses

and scholarships are available as needed for university teachers to improve their teaching competence.

3.2.2 Estonian in-service teachers

Since the beginning of data collection for the current thesis, the number of Estonian teachers has slightly increased from around 14,400 teachers in 2016/2017 to 16,300 teachers in 2020/2021 (according to the statistics of the Ministry of Education and Science, www.haridussilm.ee). Over the years, the distribution of men and women has not changed, with about 88% of in-service teachers being female. Most of the in-service teachers are older than 50 years (47% in 2016/2017), while only a small percentage of teachers are younger than 30 (10% in 2016/2017). Over the years, the average age of Estonian in-service teachers has been growing, meaning that most of the teachers received their teacher education decades ago and have years of teaching experience.

In-service teachers' professional standards are established and regulated on a governmental level, requiring at least a master's degree (except pre-school teachers) and teacher qualification. A majority of the in-service teachers hold a master's degree or equivalent qualification (45% of all general education school-teachers in 2016/2017) followed by a bachelor's degree (11% in 2016/2017). Professional competence is distinguished on three levels, namely "Teacher", "Senior teacher" and "Master teacher" (Kutsekoda, n.d.). On every level, the teachers are expected to have knowledge and skills about planning the teaching and learning process, designing the learning environment, supporting learning and development, planning professional development and reflection, supervising and working in collaboration, and carrying out developmental, creative and research activities. The required competencies are described in the professional standards, as are possibilities for professional development. If the in-service teachers move from one level to another, higher-level competencies, as well as additional competencies, are expected. Professional education courses at the university level, which serve the aim of renewing teachers' competences and knowledge (Õpetajate koolituse raamnõuded, 2019), are mostly free of charge for in-service teachers.

3.3 Study I – Assessing teachers' GPK and investigating the test instrument

3.3.1 Sample

For Study I, convenience sampling was used due to the pilot nature of the study. The purpose was to include as many participants as were accessible in order to increase diversity within the sample. The final sample for Study I consisted of 393 respondents: 170 pre-service teachers from the two universities, 175 in-service teachers from 48 schools, and 48 teacher educators from the two uni-

versities. In order to reach the pre-service teachers, invitation letters were first sent with a link to the test, and the students were then given an option to complete the test during their university coursework. In-service teachers were contacted either through their school's or professional association's e-mail lists. The schools that had a low response rate were then individually contacted by researchers and asked to distribute the test link again. The teacher educators were reached through universities' e-mail lists. Participating in the study was voluntary, and no identifiable information was collected from the participants.

The initial aim was to collect data only from pre-service teachers in their last year of studies to be either science, mathematics or Estonian language teachers. However, due to very low response rates, more pre-service teachers from different levels and curricula were contacted. The possible reason behind the low response rate of last-year students is being preoccupied during the spring semester, when their full focus is on thesis writing. Also, last-year students do not attend that many university courses, which reduces their connection to the university. Similarly to pre-service teachers, the initial aim for teacher educators was to reach those who prepare students for the ISCED 2A level (secondary education) and do not teach subject didactics. Taking into account the context, two universities together did not provide enough respondents who would fulfil these requirements. Subsequently, all teacher educators from two universities were invited to participate in the study, as they have an important role in supporting both beginning teachers' and working teachers' knowledge base. In addition, as studies have shown a close connection between subject didactics and GPK, it is important to understand all teacher educators' knowledge base.

The pre-service teachers participating in the study filled out the test in the middle of the spring semester. 70% of the respondents were studying at the bachelor's level (1st or 2nd year) and the rest at the master's level (1st or 2nd year). Out of all of the pre-service teachers, 19% were studying the curriculum to become a foreign language teacher, 15% special education, 12% kindergarten teacher, 12% science teacher and 11% Estonian language teacher. Few respondents were from the mathematics, primary school, history, physical education and vocational teacher curricula. The mean age was 27 years (min = 18 years, max = 55 years), and one third already had working experience as a teacher (min = 1 year, max = 29 years). Most of the pre-service teachers had already been attending teacher education fieldwork (48% for 1–6 months and 30% for more than 6 months).

The sample of in-service teachers consisted of 74% science teachers, 40% Estonian language teachers and/or 38% mathematics teachers on the ISCED 2A level (secondary education). 74% of the in-service teachers worked full time, and 89% had graduated from the teacher education program at a higher education institute. Teachers' working experience varied from one year to 57 years (mean 21 years). 33% of the teachers were working in a city school (100,000–500,000 inhabitants), 17% in a village school (fewer than 3000 inhabitants) and the rest in small towns. The mean age for in-service teachers was 46 years with a minimum of 23 and maximum of 79 years.

The teacher educators were most often teaching subject didactics ($n = 23$), followed by general pedagogy ($n = 22$), theories of education ($n = 16$), educational research ($n = 14$), educational psychology ($n = 14$), educational measurement and assessment ($n = 8$), history of education ($n = 3$), and sociology of education ($n = 3$). 81% of the teacher educators had graduated from teacher education studies, and 73% had also been working as a teacher at a school (mean experience 12 years, min = 1 year and max = 44 years). The mean working experience as a teacher educator was 12 years (min = 1 year and max = 38 years). 32% of the respondents were also contributing as fieldwork supervisors.

3.3.2 Instrument

A Teacher Knowledge Survey (TKS; Sonmark et al., 2017) test was used to collect data about teachers' GPK in Study I. Some of the items in the TKS were adapted from the TEDS-M test, which had been already validated and used in several studies in different contexts (e.g., König et al, 2011 and others). Other items were new and developed specifically for the TKS test by the OECD Secretariat and international experts in the teacher education field. The requirement for including newly developed items was strong empirical evidence to support the accuracy and validity of their content. All new items passed several rounds of reviews in different countries in order to remove cultural sensitivity and confirm their content reliability.

TKS followed a framework consisting of three main dimensions of GPK: instructional process, learning process, and assessment (Table 3). Guerriero (2017) has argued that these dimensions fulfil both a disciplinary and task-based approach, as was also suggested by König (2014). More specifically, the TKS GPK dimensions connect content from academic disciplines (e.g., educational psychology and didactics) and teacher tasks (e.g., classroom management). In addition to the three main dimensions, each dimension was divided into two sub-dimensions specifying the content of GPK.

Table 3. TKS dimensions, sub-dimensions and number of items.

Dimension	Sub-dimension	No of items
Instructional process	Teaching methods and lesson planning	15
	Classroom management	5
Learning process	Learning and development	13
	Affective-motivational dispositions	7
Assessment	Evaluation and diagnosis procedures	13
	Data and research literacy	7
Total		60

The final version of TKS consisted of 60 items that were either simple (43 items) or complex multiple-choice test questions (17 items). For simple multiple-choice questions, the respondents had to indicate one answer option that was correct based on their knowledge. If the item was developed as a complex multiple-choice question, the respondents had to identify the correct option for each answer row (e.g., “suitable” or “unsuitable”). Examples of the items are presented in Article II. The test was carried out in an electronic testing environment, and the participants had exactly 60 minutes to complete the test. There was no option to pause or continue later. The in-service teachers and teacher educators could choose themselves where and when they took the test (for example, at home or at the workplace). The pre-service teachers took the test during a university class as part of their coursework, and this was followed by a group discussion for self-reflection on their knowledge.

3.3.3 Data analysis

In order to prepare the dataset, all 17 complex multiple-choice questions were checked in terms of their answer patterns, and if needed, the item was converted into multiple individual items (for an example of this process, see Figure 2). This resulted in three items being divided into 13 separate variables for which the correct answer gave value 1 and the wrong answer value 0. For 13 other items, the correct answer (value 1) was given to those respondents who marked the correct answer pattern, and the rest were considered to be wrong answers (value 0). One complex multiple-choice question was removed from further data analysis because no one gave the correct answer pattern, which indicates faultiness in the item development. As a result, a dataset was generated with 69 items consisting of variables with values 0 (wrong answer) or 1 (correct answer).

In order to answer the first research question, the 1PL IRT (Item Response Theory, Rasch measurement) model was applied. 1PL IRT is recommended in the phase of piloting an instrument and to assess the quality of items. This allows researchers to test items' discrimination index and use items' difficulty as the only varying parameter. The data analysis for the first research question was carried out using Winsteps software. In order to find out the dimensionality of the instrument, the reliability of items and persons was checked together with item fit indices. For difficulty levels, a person-item map was generated and analysed in terms of the instrument's and items' difficulty. To get more insight into difficulty levels in terms of the items' structure, qualitative content analysis was applied with the aim of identifying similarities within each difficulty group and differences between the groups. As a result of the inductive analysis, three successive themes were captured.

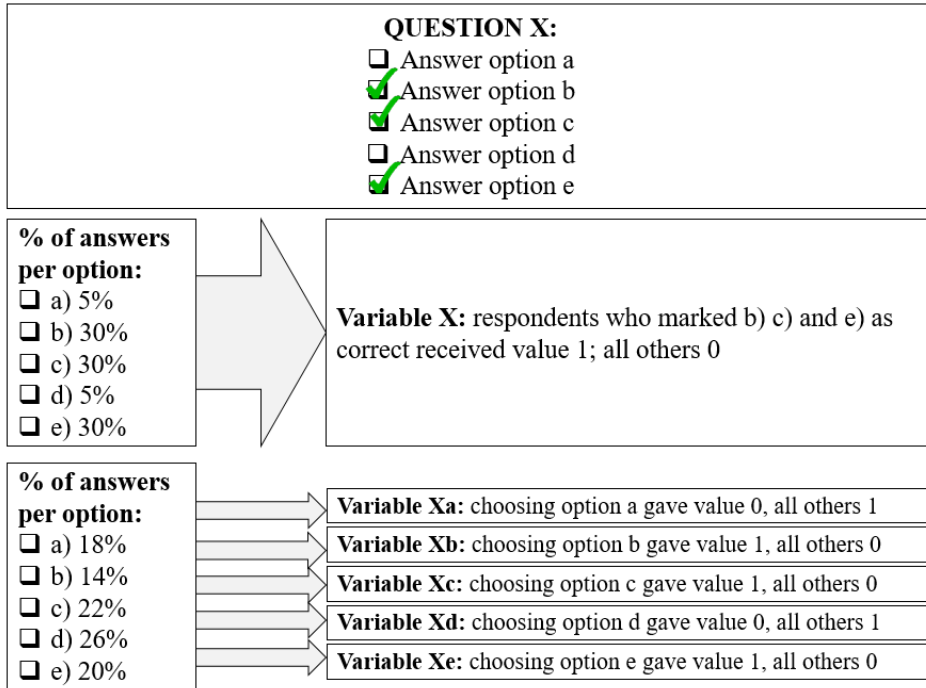


Figure 2. An example of dataset preparation for complex multiple-choice questions.

For the second research question, normal distribution of the IRT mean measure was confirmed with a Shapiro-Wilk test ($p=.06$). Due to unequal group sizes, the homogeneity of variance was checked (IRT mean measure as dependent variable and sample group as factor), showing no violation of the assumption of homogeneity of variance ($p=.12$). Therefore, an analysis of variance (ANOVA F) and Tukey HSD post hoc tests were applied in order to compare the IRT mean measures of the unidimensional instrument among three sample groups. Then, IRT differential item functioning (DIF) analysis was applied to find out how different items act among different sample groups. To look into the differences between different background variables, hierarchical linear regression was used in order to see how adding variables improves the model's ability to predict teachers' GPK, or how one variable impacts the relationships between other variables. In hierarchical linear regression, the order of entered variables is decided by researchers. In this analysis, a time sequence was taken into account when adding the variables. SPSS data analysis software was used for ANOVA and hierarchical linear regression and Winsteps software for IRT DIF analysis.

3.4 Study II – A video-stimulated recall study: GPK as practical knowledge

3.4.1 Sample

Purposeful sampling was used for Study II in order to find participants who fulfil certain criteria and are also convenient to reach due to the time-consuming nature of the data-collection process. Based on previous research and theoretical standpoints, the criteria for sampling was as follows: 1) teaching ISCED level 2 in general education school (grades 7–9 in Estonia); 2) teaching science, mother tongue, and/or mathematics; 3) minimum teaching work experience of 5 years; and 4) recognition of effective teaching by the school principal. Based on the criteria and suggestions from university-based teacher education supervisors, ten school principals were contacted. Altogether, 15 teachers were recommended, and seven teachers agreed to participate in the study. The final sample consisted of three science teachers, three mother tongue teachers and one mathematics teacher. Their teaching experience varied from 7 to 22 years. All participants had a teacher education certificate (master's degree) and worked as full-time teachers during the data collection period. An informed consent sheet was signed by each participant.

3.4.2 Data collection process

For data collection, a video-stimulated recall interview has been used as a common method for exploring teachers' knowledge (e.g., Meade & McMeniman, 1992; Schepens, Aelterman, & Van Keer, 2007; Tagle et al., 2020). To find out more about the knowledge that teachers use during teaching, a think-aloud technique has been proposed by Shavelson, Webb, and Burstein (1986). However, in the context of teaching, think-aloud has its limitations in terms of intervening in the process (Rowe, 2009). Therefore, video recording lessons and asking the respondents to recall their thoughts while watching the recordings is a suitable option (Sugrue & Day, 2002). The recall stage is often supported with semi-structured interviews in order to keep the respondents' focus (Rowe, 2009). As a result of this process, interview data is used for further analysis (Meijer et al., 2002).

In Study II, data collection was carried out in three steps. After an initial informal meeting and establishing agreements, one lesson per teacher was video recorded as the first step of data collection. As children attending the lessons were indirectly part of the research, an informed consent form was collected from 106 students and their parents in order to get approval to record the lesson. Every recorded lesson lasted 45 minutes, which is the traditional lesson duration in Estonia. The researcher was not present during the lesson, except when setting up and collecting the tablet used for recording.

For the second step, the teachers watched their own video recording independently on their own time. While watching, they were asked to fill out an observation protocol (Appendix 1) to support recalling the GPK used in the lesson. The aim of the observation protocol was to support teachers to purposefully think and recall knowledge that was used during the lesson in preparation for the interview. The observation protocol consisted of two parts: 1) dimensions from the GPK framework of TKS; and 2) empty slots for new dimensions. For each part, teachers were asked to write down a time interval from the video and mark the corresponding GPK that they thought they had been using during that instance. In addition, they were free to add any comments if needed. The purpose for using the TKS framework was to validate the GPK dimensions in the context of practical teaching.

Finally, as the third step, a semi-structured interview was carried out, supported by the video recording and observation protocol. All time intervals marked in the observation protocol were watched together with the researcher. During or after playing the video recording, teachers described the GPK they thought they had been using in a particular clip. The researcher intervened as little as possible and did not comment on anything related to the teaching profession. The semi-structured interview questions were pre-established in order to keep the focus on GPK. All interviews were audio-recorded and lasted between 27 and 52 minutes.

3.4.3 Data analysis

In order to prepare the data, all interviews were fully transcribed, and the anonymity of both teachers and students was secured (all names were removed). Then, all transcriptions were transferred to QCAmap software for qualitative content analysis (see Table 4 for an overview of data analysis steps). For the interview data that were based on observation protocol part 1, which were related to GPK sub-dimensions by teachers themselves, deductive analysis was applied. This resulted in dividing interview excerpts under the six sub-dimensions of GPK (step 1A). Then, inductive coding was carried out for every sub-dimension. For the unit of analysis, clear meaning components were used, and code names were applied (step 1B). Finally, all code names were divided into categories (step 1C).

For the interview data that was based on observation protocol part 2, an inductive analysis was applied first (2A). It became evident that the code names from part 2 match the code names from part 1, which is why it was decided to continue the analysis deductively. All code names from part 2 were divided under already established categories from part 1 (step 2B). Finally, a dataset of GPK sub-dimensions and categories under them was developed in order to describe the GPK that teachers use in their everyday practice (step 3).

Table 4. Data analysis steps for Study II.

Step	Analytical unit	Inter-rater reliability	Outcomes
1A	Dividing data from observation protocol part 1 under GPK sub-dimensions	Segments from interviews, supported by the observation protocol	Data divided under sub-dimensions
1B	Inductive analysis of sub-dimensions (part 1)	Clear meaning component in the data	First co-researcher assigned code names to two interviews. Result: Cohen's Kappa = .75
1C	Organizing code names under categories (part 1)	Code names per sub-dimension	Categories were formed per sub-dimension
2A	Inductive analysis of observation protocol part 2	Clear meaning component in the data	Code names assigned
2B	Deductive analysis to divide codes under categories formed from part 1	Code names	Code names from part 2 were divided under categories from part 1
3	Forming a set of sub-dimensions, categories and codes	–	1) Second co-researcher assigned code names to two excerpts from every sub-dimension (outcome: consensus based on discussion). 2) Distribution of the code names under categories and categories' names were confirmed with third co-researcher.
4A	Finding similarities between sub-dimensions	Code names	Identified overlapping themes of sub-dimensions
4B	Using sensitizing concept for organizing the overlapping themes	Overlapping themes	Ajzen's (1985) theory as sensitizing concept for organizing the overlapping themes
5	Concluding the overlapping themes	–	Final set of sub-dimensions and overlapping themes

To find possible connections between GPK dimensions, as is suggested in the results of Study I, similarities among code names across all sub-dimensions were searched (step 4A). After determining the overlapping themes, Ajzen's (1985) theory was found to be necessary as a sensitizing concept. Based on his planned behaviour theory, all connecting themes were marked as either a teacher's intention or teacher's activity (step 4B). Lastly, a set of overlapping themes among sub-dimensions was finalized (step 5).

To support the credibility of the qualitative content analysis, four rounds of reviews with other researchers were carried out. The purpose of these review rounds was to compare and discuss the interpretations and seek agreement. The first round of review was carried out during the inductive analysis process based on interview data from observation protocol part 1 (step 1B). During the first round of review, the first co-researcher coded two interviews independently without any discussion between the researchers. After that, Cohen's Kappa was calculated in order to check the consistency of code names between the two researchers. As a result, a good inter-rater reliability of .75 was found. Some minor differences appeared at the level of generalization (e.g., *supporting learning* versus *supporting memory*). All differences were discussed, and consensus was reached. The second round of review was carried out when the initial categories and codes under every sub-dimension were established (step 3). A second co-researcher was given two excerpts from each GPK sub-dimension and asked to generate code names. Three excerpts required further discussion, as the code names varied between two researchers. Again, the discussion was related to the level of generalization, and as a result, consensus was reached. Then, the distribution of code names under categories was checked by a third co-researcher in the third round of review (step 3). Minor revisions were done, such as revising the names of categories and merging two small categories into one. Lastly, as the fourth round of review, the main researcher, second co-researcher, and third co-researcher discussed in detail the themes that were found to connect GPK dimensions (step 4B). During that process, the connecting themes were divided under Ajzen's (1985) theory of planned behaviour theory – intention and activity.

In order to enhance the internal validity in a qualitative study, different types of triangulation were ensured: triangulation by data source, indirect triangulation by method, and triangulation by researcher (Miles & Huberman, 1994). The application of triangulation is presented in Table 5.

Table 5. Types of triangulation applied in Study II.

	Sample	Data collection process	Data analysis
Data source triangulation	Different persons from different schools		
Method triangulation (indirect)		Combination of video recording, observation protocol and semi-structured interview	
Researcher triangulation			Four researchers involved in data analysis process

4. FINDINGS

4.1 Study I – Assessing teachers' GPK and investigating the test instrument

4.1.1 Quality of the pilot GPK test instrument in an Estonian context

The quality of the pilot GPK test (TKS) instrument was investigated through the dimensionality and difficulty of the instrument in an Estonian context. It was initially hypothesized that the instrument would measure GPK as one dimension, as suggested in the research literature. If the Infit and Outfit parameters of the 1PL IRT model are 1.00, the data fits the Rasch model according to Bond and Fox (2015). Upon testing the instrument data with the Rasch measurement, both parameters were 1.00, suggesting that the instrument was unidimensional. The item reliability was .99, showing consistency in terms of item difficulty among different sample groups. The overall person reliability, on the other hand, was a moderate .67, implying heterogeneity among items. When checking each GPK dimension separately, the person reliability was .40 for instructional process dimensions, .46 for the learning process dimension and .24 for the assessment dimension. The very low person reliability on dimensions when measured separately provides more evidence toward the assumption of unidimensionality.

In order to increase the person reliability, fit statistics for each item were checked (see Article II). As a result, 18+1 items (an additional item was removed due to other three answer options from the complex multiple-choice item showing weak fit indices) were identified as problematic with a negative point-measure correlation (PTMA) lower than .15, suggesting that a low-score participant has a higher chance of giving the correct answer to these items than a high-score participant (Bond & Fox, 2015). Due to this, 19 items out of 69 were removed from further analysis. Most problematic items originated from the *learning and development* and *evaluation and diagnosis procedures* sub-dimensions (seven and six items removed, respectively), while the sub-dimension of *affective-motivational dispositions* did not have any problematic items, and the research literacy sub-dimension had only one.

After excluding items with weak fit indices, the unidimensionality hypothesis was tested again. The overall person reliability had increased from .67 to .77, showing better consistency among items and again outperforming the reliability of the dimensions separately (Figure 3). Accordingly, it can be concluded that the result of the GPK test is more reliable if all items are used together as unidimensional instead of separating different dimensions. Due to this phenomenon, the results of Study I were then based on the dataset of 50 included items showing good fit indices and forming a reliable unidimensional instrument.

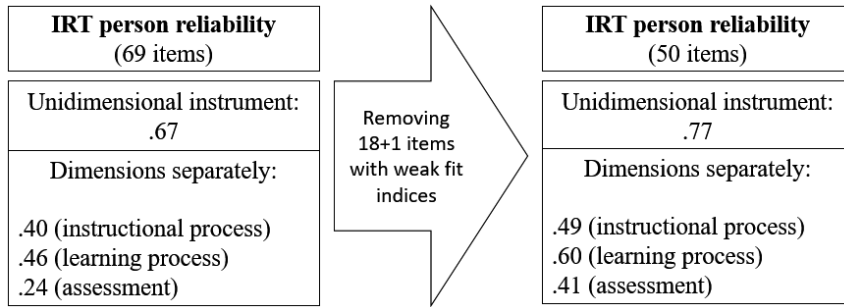


Figure 3. Changes in person reliability for the unidimensional instrument and for dimensions measured separately.

The second step in investigating the quality of the TKS instrument was to look at the difficulty level of each item. The difficulty levels are important for interpreting test results, as a more diverse range of difficulty gives more possibilities to differentiate the respondents. Also, as the test is designed for three different sample groups, distinguishing meaningful difficulty levels gives an opportunity to provide additional information about the GPK of a sample group.

In order to distinguish the difficulty levels, an IRT person-item map was developed with a scale based on items (see Article II). The person mean measure was .59 (SD = .76) with a minimum of -2.37 and maximum of 3.44 (item mean set to .00), indicating that the test was relatively easy for the respondents, as for 30 items out of 50 they had a greater than 50% chance to give a correct answer. Therefore, it is necessary to look at the items and explore the possible reasons behind easier as well as more difficult items. In order to do so, a qualitative content analysis was carried out on the items.

In preparation for the analysis, items were divided into three difficulty groups based on the person-item map (easy items' difficulty level was rated from -4 to 0, moderate items difficulty level from 0 to 1.5, difficult items difficulty level from 1.5 to 3). As a result, three themes were found that might distinguish the three difficulty groups.

The items in the easiest group were mostly based on situation descriptions and had a clear connection to practice rather than theory. It can be assumed that it is possible to answer those questions with common sense and knowledge from practical experience. The moderate difficulty level also had situation-based questions; however, they were connected to some specific theoretical concept. It can be presumed that answering those questions required connecting knowledge both from theory and practice. The most difficult level asked about specific theoretical concepts and focused more on the definitions of concepts. This means that answering these questions is based only on theoretical knowledge, and they can be solved without practical experience. Example questions from each difficulty group are presented in Article II, and examples of typical wording that represent the item levels are shown in Table 6.

Table 6. Examples of similarities among the items and their wording in each difficulty level (Article III).

Difficulty level	No of items	Examples of items
Difficult: only theory (person-item map level 1.5 to 3)	5	<i>Which of the following definitions represents Vygotsky's proximal development theory?</i>
Moderate: situation description connected to theory (person-item map level 0 to 1.5)	25	<i>Mrs. Jones, a science teacher, would like to apply formative assessment in her course. Which of the following strategies is best suited for this type of assessment?</i>
Easy: situation description (person-item map level -4 to 0)	20	<i>Mrs. Miller, the mathematics teacher, has noticed that one of her pupils is avoiding the assigned task and is instead scribbling on a piece of paper. Previous topics have not been difficult for the pupil. Which of the following activities would help the struggling pupil the best and would also enhance the pupils' cooperation with each other?</i>

In conclusion, the analysis of item difficulty revealed that the most difficult items for respondents are those that are completely based on theoretical knowledge. However, the person-item map also shows how the proportion of such items is much smaller compared to the other two difficulty levels, and overall, this indicates that the test is rather easy. Therefore, in order to increase the quality of the instrument, more difficult items would be needed, as targeting a wider ability range ensures even higher person reliability.

4.1.2 Differences between the GPK of pre-service teachers, in-service teachers and teacher educators

In order to explore how the overall GPK differs among the three sample groups, comparison tests for the overall IRT mean measure as well as on the item level were carried out. In a test development process, it is important to understand how the instrument behaves among target groups and if it is possible to use the same instrument for different sample groups. In order to be able to differentiate respondents, which would give more empirical information on GPK, the test instrument must be moderately difficult for every sample group.

Firstly, an overall IRT mean measure was calculated for each sample group, as the analysis suggested higher reliability for the unidimensional approach, and the mean measures were compared with ANOVA F (Table 7). The results showed a very similar outcome for both pre-service teachers and in-service teachers, with mean measures of .49 and .50. Teacher educators, as expected, outperformed other groups with a mean measure of 1.30. The Tukey HSD post

hoc test revealed significant differences between pre-service teachers and teacher educators ($p=.00$) as well as between in-service teachers and teacher educators ($p=.00$).

Table 7. ANOVA results of the unidimensional GPK among three sample groups.

	No of items	IRT mean measure			F (df _{between} , df _{within})
		Pre-service teachers	In-service teachers	Teacher educators	
Unidimensional GPK	50	.49	.50	1.30	24.000 (2, 367)*

* $p < .01$

In order to find possible differences in difficulty levels among the three sample groups – pre-service teachers, in-service teachers, and teacher educators – a differential item functioning (DIF) analysis was applied. The differences were analysed at the item level rather than by the dimension or the whole instrument. This approach gives more specific results and is more informative for future test development.

The results showed that all of items that were significantly more difficult for pre-service teachers than the other groups fell into the dimensions of learning process or assessment (see also Article II). The difficult items from the learning process dimension were mostly focused on specific terms and theoretical concepts (e.g., orientation towards failure), and the differences appeared in comparison with in-service teachers. Within the assessment dimension, the difficult items mostly asked about research methods. As described in the sample section, the pre-service teachers studied at different levels, and therefore, many of them had not taken a research methods course yet. The theoretical questions from the learning process dimension also indicate that some topics might have been removed from the teacher education curriculum over the years. As items about research methods and specific theories were more difficult for pre-service teachers, it may indicate that certain types of knowledge are acquired at the end of or after finishing teacher education studies. From a test development perspective, this difference provides an opportunity to monitor pre-service teachers' knowledge growth.

As for in-service teachers, similar patterns repeated, but the exact items were different. The in-service teachers group struggled the most with specific theoretical knowledge, for example, about neuroscientific concepts and Bloom's taxonomy. All these items are expected to prompt teachers to recall definitions that might have been forgotten over the years. However, there was no connection to real life that might have provided a more suitable context for in-service teachers. For test development, when assessing different sample groups with the same instrument, it is important to frame the knowledge in the most suitable form for all sample groups so that pre-service teachers and teacher educators would not have an advantage due to their everyday contact with educational theories.

Teacher educators, in contrast with the other sample groups, struggled more with items that demanded solving a practical situation in a school context and where no clear connection was made to any theoretical concept. Again, this informs the suitability of the instrument for three sample groups as certain types of questions are either more difficult or easier for certain types of sample groups.

4.1.2.1 Background variables related to differences in GPK

As presented above, differences in GPK appear between pre-service teachers, in-service teachers and teacher educators, showing how some types of items are easier or more difficult for some sample groups. In addition to differences between the groups, the variables related to differences in GPK were also checked inside the groups. To do this, hierarchical linear regression was carried out with the IRT mean measure as an independent variable. Hierarchical linear regression allows researchers to explore the increments in variation accounted for through adding predictors over a set of models. If the R-square indicator increases significantly after the inclusion of predictors in different steps, we can conclude that the predictors added at that step provide increasing predictive power. Before running hierarchical linear regression models, the multicollinearity was checked within each sample group, and the collinearity statistics ($VIF < 10.000$; $Condition\ Index < 15.000$) were all within accepted limits.

In order to find the variables predicting pre-service teachers' GPK, their study level (1 = BA 1st year; 2 = BA 2nd year; 3 = BA 3rd year; 4 = MA 1st year; 5 = MA 2nd year) was entered at step one in the hierarchical linear regression model, months of pedagogical traineeship (1 = none; 2 = 1 month; 3 = 2–3 months; 4 = 4–6 months; 5 = 7–12 months; 6 = more than 12 months) was entered at step two, teaching job experience (0 = no; 1 = yes) was entered at step three and other educational job experience (0 = no; 1 = yes) was entered at step four. Other educational jobs include, for example, one-on-one tutoring, working in ministry, or working in an educational agency. The sequence of variables added depends on their typical occurrence, as pre-service teachers should usually start with their studies and then move on to the practical field. The hierarchical linear regression revealed (Table 8) that the study level contributes significantly to the regression model ($F(1,150) = 13.09$, $p < .01$) and accounts for 7% of the variation in GPK. In step one, the study level significantly influences the increase of GPK. Adding the variable of pedagogical traineeship, the model ($F(2,149) = 8.90$, $p < .01$) explains an additional 0.3% of variance in GPK with a significant R^2 change, with the new variable significantly decreasing the GPK. Then, adding the teaching experience variable and the regression model ($F(3,148) = 6.58$, $p < .01$) explains an additional 0.1% of the variation in GPK; however, this change is not significant. Finally, adding the other job experience variable, the regression model ($F(4,147) = 6.49$, $p < .01$) explains an additional 0.3% of the variation in GPK, with a significant change in R^2 . With this change, the pedagogical level does not significantly influence GPK; however, other educational job experience does increase GPK.

Table 8. Results of hierarchical linear regression for variables predicting pre-service teachers' general pedagogical knowledge (IRT mean measure as a constant).

Variable	Adj. R ²	ΔR^2	β	B	SE B
Step 1	.07	.08			
Study level			.28**	.15	.04
Step 2	.10	.03*			
Study level			.25**	.13	.04
Pedagogical traineeship			-.17*	-.08	.04
Step 3	.10	.01			
Study level			.22**	.12	.04
Pedagogical traineeship			-.18*	-.08	.04
Teaching experience			.11	.18	.13
Step 4	.13	.03*			
Study level			.21**	.11	.04
Pedagogical traineeship			-.14	-.07	.04
Teaching experience			.09	.14	.13
Other educational job experience			.18*	.28	.12

*p<.05; **p<.01

For in-service teachers, months of pedagogical traineeship (1 = none; 2 = 1 month; 3 = 2–3 months; 4 = 4–6 months; 5 = 7–12 months; 6 = more than 12 months) was entered at step one, as traineeship takes place earlier than the other variables (during teacher education). Graduation from teacher education (0 = no; 1 = yes) was entered at step two, teaching experience in years at step three, and other educational job experience (0 = no; 1 = yes) was entered at step four. The results (Table 9) showed that pedagogical traineeship has no significant contribution to the regression model ($F(1,154) = .06, p>.05$). Adding the variable of teacher education graduation does not change the statistical significance of the model ($F(2,153) = .26, p>.05$). However, in step three, the years of teaching experience contribute significantly to the regression model ($F(3,152) = 3.61, p<.01$), explaining 5% of the variation in GPK and decreasing the GPK. Finally, other educational job experience increases the efficacy of the model to explaining 6% of the variation, with a significant contribution to the overall model ($F(4,151) = 3.56, p<.01$).

Table 9. Results of hierarchical linear regression for variables predicting in-service teachers' general pedagogical knowledge (IRT mean measure as a constant).

Variable	Adj. R ²	ΔR^2	β	B	SE B
Step 1	-.01	.00			
Pedagogical traineeship			.02	.01	.05
Step 2	-.01	.00			
Pedagogical traineeship			.04	.03	.05
Graduation from teacher education			.06	.08	.11
Step 3	.05	.06**			
Pedagogical traineeship			.04	.03	.05
Graduation from teacher education			-.05	-.06	.12
Teaching experience			-.27**	-.01	.00
Step 4	.06	.02			
Pedagogical traineeship			.03	.02	.05
Graduation from teacher education			-.07	-.08	.12
Teaching experience			-.24**	-.01	.00
Other educational job experience			-.15	-.18	.10

*p<.05; **p<.01

In the sample group of teacher educators, graduating from teacher education (0 = no; 1 = yes) was added in step one of the hierarchical linear regression model, as graduation from teacher education should occur before teaching experience (0 = no; 1 = yes), which was added in step two. Then, teacher educator experience in years (continuous variable) was added in step three and finally, supervising pedagogical traineeship (0 = no; 1 = yes) was entered in step four. The hierarchical linear regression analysis results (Table 10) revealed that graduation from teacher education alone explains 7% of the variance in teacher educators' GPK ($F(1,43) = 4.07$, $p < .05$); however, the change in knowledge has a negative direction if the participant has graduated from teacher education. When teaching experience is added to the model, the model ($F(2,42) = 2.17$, $p > .05$) is not significant and none of the variables show significant contribution to GPK. The model remains similar when adding teacher educator experience, explaining 6% of the variance, and the model is not significant ($F(3,41) = 1.98$, $p > .05$). Finally, the variable of supervising pedagogical traineeship showed a significant contribution to the regression model ($F(4,40) = 3.98$, $p < .01$), explaining 21% of the variance in GPK. Supervising pedagogical traineeship significantly decreases GPK.

Table 10. Results of hierarchical linear regression for variables predicting teacher educators' general pedagogical knowledge (IRT mean measure as a constant).

Variable	Adj. R ²	ΔR^2	β	B	SE B
Step 1	.07	.09			
Graduation from teacher education			-.29*	-.50	-.25
Step 2	.05	.01			
Graduation from teacher education			-.21	-.35	.36
Teaching experience			-.12	-.19	.33
Step 3	.06	.03			
Graduation from teacher education			-.13	-.22	.37
Teaching experience			-.09	-.15	.33
Teacher educator experience			-.21	-.02	.01
Step 4	.21	.16**			
Graduation from teacher education			-.15	-.25	.34
Teaching experience			.03	.05	.31
Teacher educator experience			-.20	-.12	.01
Supervising pedagogical traineeship			-.41**	-.61	.21

*p<.05; **p<.01

In conclusion, most of the statistically significant variables predicting GPK were related to teaching practice (pedagogical traineeship, teaching experience, supervising pedagogical traineeship), and the direction of prediction was negative. For pre-service teachers, study level and having other educational job experience contributed to the increase of GPK. From a test development perspective, the results show that the TKS instrument is easier for respondents that are not involved in teaching practice and who have a rather higher level of education and wider job experience.

4.2 Study II – A video-stimulated recall study: GPK as practical knowledge

4.2.1 GPK dimensions in everyday teaching

The framework from the TKS instrument was used to identify the GPK that is used in everyday teaching. The deductive analysis revealed that teachers mostly identify GPK among the following sub-dimensions: *classroom management* (marked 29 times in the observation protocol), *learning and development* (marked 29 times), *teaching methods and lesson planning* (26 times) and *affective-motivational dispositions* (23 times). The sub-dimensions of *evaluation and diagnosis procedures* (marked 4 times) and *research literacy* (marked 2 times) gained significantly less attention in practical teaching.

Analysis of the interviews resulted in several categories for each sub-dimension that presents the specific knowledge that teachers recognized using during their teaching (Figure 4). In the sub-dimension of *teaching methods and lesson planning*, teachers identified using knowledge that was related to classroom guidance, building students' interest and motivation, presenting and reinforcing knowledge, choosing and using different teaching practices and tools, as well as planning activities and goals. The *classroom management* sub-dimension was more related to behavioural issues, such as managing behaviour matters, directing and keeping students' attention, and managing the activities taking place in the classroom. Knowledge in the *learning and development* sub-dimension included providing differentiated support and communication, choosing and using methods and tools to support cognitive processes, guiding students in recalling and integration of knowledge, as well as providing emotional support and communication with the students. The *affective-motivational dispositions* sub-dimension was described as using motivating methods and tools, providing help to students, and supporting their interest. The sub-dimension of *evaluation and diagnosis procedures* was divided into two categories, namely, teachers giving feedback to students and supporting students' self-assessment. The detailed content of the first five sub-dimensions and their categories is presented in Article III.

The *data and research literacy* sub-dimension, which appeared more during the inductive analysis of the observation protocol in part 2, was mostly described as supporting students' research literacy, as well as on a few occasions of noting research-based teaching. This sub-dimension presented the most differences between the content of the TKS instrument and teachers' practice. While TKS items focus more on detailed knowledge of research methodology (e.g., reliability, correlation, standard deviation, etc.), teachers mainly described activities and tasks used to enhance students' research literacy. For example, they brought up examples of how they learn to interpret and present data, as well as write academic papers. TKS items, on the other hand, were developed from the teachers' point of view, reflecting how teachers can use research-related knowledge to enhance their own teaching and students' learning. This, however, was rarely mentioned by the teachers. The results and differences between TKS and teachers' interviews point out a need to improve the conceptualization of the *data and research literacy* sub-dimension as part of GPK. More specific analysis of this sub-dimension is presented in Article IV.

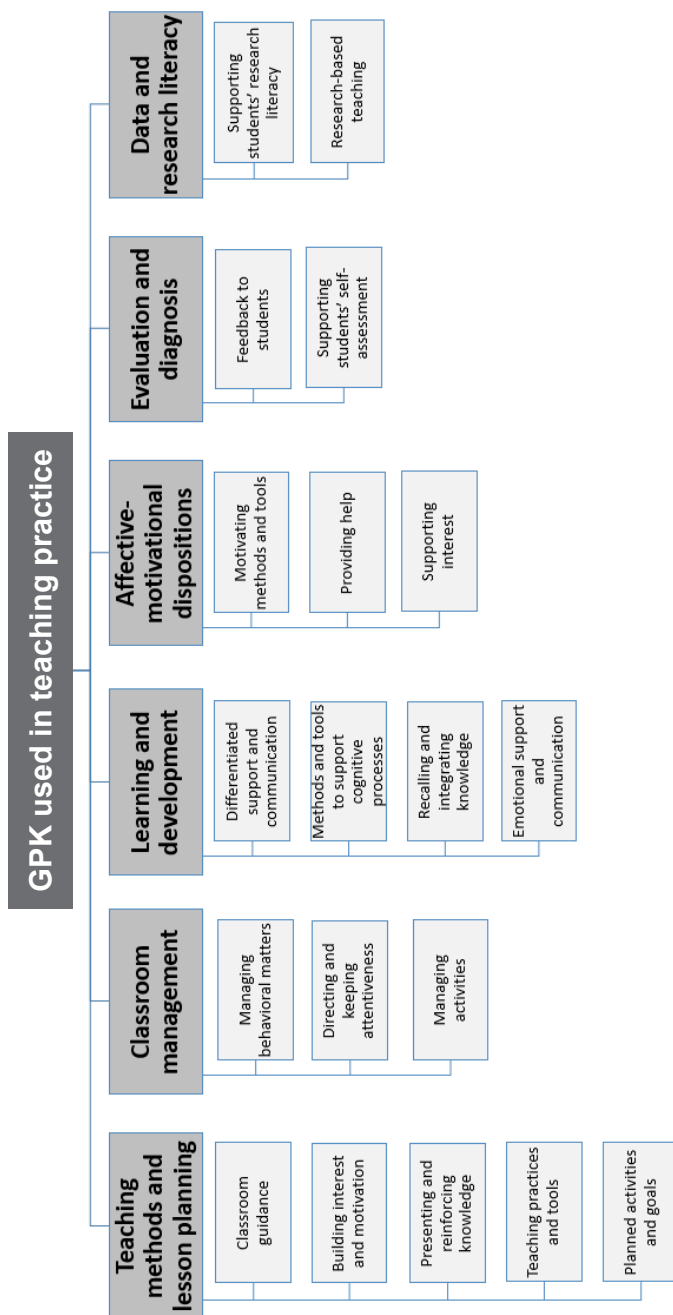


Figure 4. Sub-dimensions and categories of GPK that teachers identified using in their teaching practice.

4.2.2 Connections between GPK dimensions in everyday teaching

While analysing the content of sub-dimensions that teachers identified in their teaching practice, the overlapping nature of the GPK sub-dimensions was captured. As a result, ten overlapping themes were identified that describe the connections between sub-dimensions (Table 11), and using Ajzen's (1985) theory of planned behaviour as a sensitizing concept, it was found that GPK dimensions are connected at the level of teachers' intentions and teachers' actions. However, the *data and research literacy* sub-dimension did not share any overlapping themes.

Table 11. The overlapping themes between GPK sub-dimensions as described by teachers.

		GPK sub-dimension					
		Teaching methods and lesson planning	Classroom management	Learning and development	Affective-motivational dispositions	Evaluation and diagnosis procedures	Data and research literacy
Overlapping theme	Intention	Learning outcome					
		Interest					
		Wellbeing					
		Motivation					
		Attention					
	Activity	Differentiation					
		Giving instructions					
		Behavioural management					
		Praise and support					
		Time management					

Grey colour indicates the occurrence of the theme in the sub-dimension.

The most common overlapping theme among teachers' intentions was the *learning outcome*, which was mentioned and described throughout five GPK sub-dimensions. In the sub-dimensions of *teaching methods and lesson planning*, *classroom management*, and *learning and development*, the learning outcome theme was repeatedly emphasized when talking about teaching methods and activities that aim to recall previously learned knowledge, introduce new knowledge or consolidate already existing knowledge. In the *learning and development* sub-dimension, the importance of memory and information processing

was also brought up, as they lead to learning outcomes. *Affective-motivational dispositions* represent learning outcomes in terms of teachers' intention to motivate the students to reach the learning outcome though offering rewards and taking into account their students' individual levels. In the sub-dimension of *evaluation and diagnosis procedures*, assessment criteria and giving feedback emerged together with the aim of reaching learning goals. The interview excerpts in Table 12 show how learning outcome as an intention was positioned under the first five GPK sub-dimensions.

Table 12. Excerpts showing the overlapping theme of learning outcome.

GPK sub-dimension	Category	Excerpt	Overlapping theme
Teaching methods and lesson planning	Planned activities and goals	<i>"These goals I set for myself, to see where I want to go with this lesson and what is important for students, are for <u>the knowledge that they have gained by the end of the lesson.</u>"</i>	LEARNING OUTCOME
Classroom management	Managing activities	<i>"I am fully aware that at the beginning of every lesson after saying 'hi', I tell them what they should expect today: for how long and <u>where we are going to go with it.</u>"</i>	
Learning and development	Methods and tools to support cognitive processes	<i>"It is important that if you write anything on the board you definitely need to read it aloud at the same time. It is that some of them listen, but they are not so fast to always look at the board. But if they listen to what I say, then the chance is greater that <u>they will understand it.</u>"</i>	
Affective-motivational dispositions	Motivating methods and tools	<i>"And it [learning content] should be seen, the teacher should also work in front of the blackboard, so it is not only the student, but we all reach the learning goal together."</i>	
Evaluation and diagnosis procedures	Pupil self-assessment	<i>"Everybody will read aloud what they wrote on the paper. /.../ That they themselves think, and I believe they do it, they must think of <u>what their learning outcomes are and what they achieved.</u>"</i>	

Supporting students' *interest* was a topic across the first four sub-dimensions. Again, in the *teaching methods and lesson planning* sub-dimension, interest was taken into account when planning teaching methods for presenting knowledge, for example, using emotional study materials, giving real life examples, and using different technology. In the *classroom management* sub-dimension, teachers mentioned students' interest as an important aspect to consider when supporting their motivation, focus and attentiveness. The *learning and development* sub-

dimension added interest as a tool to support students' autonomy. From the sub-dimension of *affective-motivational dispositions*, supporting interest was mainly described in terms of using enjoyable teaching tools and playful elements. Across all four sub-dimensions, teachers pointed out real life examples as a tool to keep up students' interest in learning content.

Teachers also shared their knowledge about ensuring students' *wellbeing*. In the *teaching methods and lesson planning* sub-dimension and the *classroom management* sub-dimension, students' wellbeing was encouraged through adding physical activity to the learning process. Also, creating a good learning atmosphere with no disturbing factors (e.g., disturbing behaviour) was a topic that teachers described as important to ensuring students' wellbeing when choosing the teaching methods and managing the classroom. The *learning and development* sub-dimension and the *affective-motivational dispositions* sub-dimension approached wellbeing as teachers' knowledge to provide emotional support in anxious situations, build a trusting relationship and be an equal person with the students. In addition, motivational teaching tools and positive feedback were described as the basis of students' wellbeing.

Even though *motivation* stands for a separate sub-dimension, the topic was also included when talking about *classroom management* and *teaching methods and lesson planning* sub-dimensions. In terms of lesson planning, teachers described how they need to know which motivating activities and tools to use in an upcoming lesson. Motivation was also something that was noted as an important aspect in order to keep students' attention on learning content. *Attention* became the most important theme for the *teaching methods and lesson planning* sub-dimension and the *classroom management* sub-dimension. The first sub-dimension takes attention into account in planning lesson activities and teaching methods that support constant attentiveness, e.g., using emotional study materials and making connections to real life that grasp students' attention. In terms of classroom management, teachers mostly emphasized the importance of attention in order to prevent disturbing events.

In terms of teachers' activity, *differentiation* of teaching became a recurrent theme in five sub-dimensions. In the sub-dimension of *teaching methods and lesson planning*, differentiation was mentioned as part of knowledge when choosing appropriate teaching methods while considering possible special needs. In terms of the *classroom management* sub-dimension, differentiation was highlighted as an important activity that helps teachers to ensure students' motivation, attentiveness and focusing, which in turn are important for successfully managing the whole classroom. The *learning and development* sub-dimension and the *affective-motivational dispositions* sub-dimension consider differentiation more on an individual level, taking into account every student's autonomy and individual level in the learning process. Finally, in *evaluation and diagnosis procedures* sub-dimension, teachers found differentiation to be important in the process of formative evaluation and also to support students' skills to give feedback on their own work. The excerpts showing the overlapping theme of differentiation are presented in Table 13.

Table 13. Excerpts showing the overlapping theme of differentiation.

GPk sub-dimension	Category	Excerpt	Over-lapping theme
Teaching methods and lesson planning	Teaching practices and tools	<i>„I have many different methods. With him I have to be very creative during the lesson. <u>So if I see that something doesn't work I have to come up with something else real quick.</u>”</i>	DIFFERENTIATION
Classroom management	Managing activities	<i>“This is a really interesting class. There are couple of bilingual students. /.../ <u>For them it is really good to explain some of the things [instead of using flipped classroom].</u>”</i>	
Learning and development	Methods and tools to support cognitive processes	<i>“If something does not work, I quickly change. /.../ For this student it is important that he can touch the physical object, so that it exists to him.”</i>	
Affective-motivational dispositions	Providing help	<i>“So everyone wants to get praise. But if I ask student a difficult question and he cannot and cannot answer, then this is not motivation. On the contrary, this decreases all the interest. Like the student is now in an embarrassing situation. But then I think, <u>I ask directed questions, which questions goes to who.</u> Then I don't put the student in a bad situation.”</i>	
Evaluation and diagnosis procedures	Feedback to pupil	<i>“Well, giving feedback. So, I think that maybe that much of recognition of pupils at the moment, that oh how good you were, you answered very well, that maybe this was here, I mentioned that it was a correct answer, it's like <u>I gave a sign that he is on the right path</u>”</i>	

A theme of *giving instructions* was repeatedly brought up as having a big role in teaching in general. More specifically, teachers claimed to take instructional knowledge into account when choosing the teaching methods in the *teaching methods and lesson planning* sub-dimension, as well as when solving behavioural issues and presenting new knowledge in the sub-dimension of *classroom management*. Giving instructions was also emphasized as something to consider when thinking about aspects related to students' learning and development, for example, how to support every student's learning process during the instructional period. Finally, giving instructions plays a role in motivating students to take part in an activity, but it is also important to vary methods to keep students motivated.

Behavioural management became a topic not only in the *classroom management* sub-dimension, but also when talking about *teaching methods and lesson planning*, as well as *learning and development*. Teachers described how they need to know which teaching methods they will plan to use in order to manage behavioural issues and create a good learning atmosphere, but also to be ready for any adaptations that are necessary. *Praise and support* connected the sub-dimensions of *learning and development*, *affective-motivational dispositions*, and *evaluation and diagnosis procedures*. If in the first sub-dimension mentioned, the emphasis was mostly on relationships and emotional support, then the second one was more focused on offering rewards and personal help in order to solve study-related problems. In terms of evaluation, praise and support were mentioned as part of assessment (e.g., formative evaluation) and the teacher's feedback to students. The sub-dimensions of *teaching methods and lesson planning* and *classroom management* were also connected with the theme of *time management* in order to choose accurate teaching methods that are doable in the given time frame, as well as understanding how to present a lesson plan to the students in the beginning of the lesson in order to manage it from the start.

In conclusion, the GPK that is used in everyday teaching practice seems to be connected at two levels, namely intention and activity (Ajzen, 1985). According to Ajzen's (1985) theory of planned behaviour, intention is an individual's self-prediction of the probability that they will apply some specific actions. In this study, teachers' intentions in terms of using GPK were related to supporting students' learning outcomes, interest, wellbeing, motivation and attention. Action, on the other hand, is the realization of intention according to this theory. Therefore, based on the results of the study, it seems that teachers' intentions are realized through giving instructions, behavioural management, praise and support, time management, and differentiation.

5. DISCUSSION

The aim of this doctoral thesis was to investigate a pilot instrument for assessing teachers' GPK and to gain more insight into the dimensions of GPK that teachers use in everyday teaching practice. The first part of the aim was reached by analysing a test instrument that was completed by Estonian pre-service teachers, in-service teachers and teacher educators. As the results suggested that the test items are rather distant from the knowledge that is used in teachers' everyday work, video-stimulated recall interviews were carried out with practicing teachers about GPK used in the classroom. These two studies contributed to building an understanding of teachers' GPK, how it is approached in research, and how it is applied in practice. In the following section, the results of this doctoral thesis are discussed in connection to theoretical standpoints and previous empirical findings. Finally, scientific and practical implications, as well the limitations of the study and directions for further research, are addressed.

5.1 The nature of teachers' GPK in assessment and practice

The scientific literature shows that in addition to defining GPK, researchers also distinguish the dimensions of GPK as the specific content of that knowledge domain. GPK dimensions have also been used in specific scales when measuring teachers' knowledge (e.g., TKST and TEDS-M instruments). In this thesis, it was found that GPK is a unidimensional construct, as the reliability score is the highest when considering all dimensions together. A similar result has been obtained in research on the TEDS-M instrument (e.g., König, 2013; König et al., 2011, 2016), showing that the separate dimensions present lower reliability compared to the unidimensional model. However, the unidimensional nature of GPK does not necessarily exclude the idea of GPK dimensions, as they compose a framework of specific topics (König et al., 2011). Every dimension in this framework has a role in building the base of knowledge, and teachers as professionals can have their own strengths and weaknesses in GPK (König et al., 2011; Voss et al., 2011).

Being aware of how the different dimensions contribute to the overall GPK framework and how these are connected in the unidimensional construct can help researchers to approach GPK more precisely. The results of the current thesis suggest that GPK dimensions are linked with each other through teachers' intentions to support their students' learning and development as well as through the activities teachers apply to support learning and development in the learning process. Therefore, Ajzen's (1985) theory of planned behaviour can be taken into account when developing instruments for measuring GPK. Also, in previous studies, supplementary frameworks have been applied when developing the items for a GPK test. For example, König (2014) proposed that GPK can be approached based on its cognitive demand (recall or analyse). Sonmark et al. (2017), based

on the work of Shalem (2014), applied type of knowledge (theoretical or practice-based) as a supplementary measurement to every item. Nevertheless, these attempts are more focused on the source or processing of the knowledge, rather than the nature of GPK that is used in the practice. Being aware of what connects GPK dimensions, based on the GPK used in practice, gives researchers an opportunity to develop more valid instruments. For example, taking into account the role of motivation in the dimensions of *teaching methods and lesson planning* and *classroom management*, as opposed to only in the *affective-motivational dispositions* dimension, allows researchers to be more accurate in terms of measuring the unidimensional knowledge that is applied in practice for effective teaching.

Understanding and applying the overlapping nature of GPK dimensions is not the only challenge when it comes to measuring GPK. Previous research has shown patterns of GPK increase that can validate the accuracy and nature of GPK tests. In terms of pre-service teachers, König (2013) found that GPK increases throughout their teacher education studies and Klemenz et al. (2019) have added that different learning opportunities do have an impact on the growth of GPK. After graduation, the increase of GPK should continue as the practice demands constant updating and learning (Choy et al., 2013; König, 2013). In this doctoral thesis, the investigation of the TKS instrument suggests that GPK might increase across the study level of pre-service teachers, providing evidence that pre-service teachers' knowledge is systematically supported over time. Similarly to research with the TEDS-M instrument, TKS has been shown to be valid in terms of the curriculum and conceptualization of the instrument (König, 2013). Pre-service teachers' data also showed that other educational job experiences increase GPK. It can be assumed that these experiences (e.g., private tutoring, working in ministry) provide pre-service teachers a wider perspective, and they are more predisposed to work and learn in the educational area. Also, having better results among pre-service teachers who have other educational job experiences can be an indication that the GPK assessed in TKS is not only or directly connected to teaching.

In accordance with that assumption, variables directly related to teaching practice showed opposite results of what is suggested in previous research. In brief, the results from TKS showed that pre-service teachers', in-service teachers' and teacher educators' level of GPK is lower when they possess more teaching practice. In addition, the knowledge level of pre-service teachers and in-service teachers was very similar, contradicting the research on teachers' GPK development (e.g., Choy et al., 2013). These results suggest that the TKS instrument does not assess knowledge that is used in practice, as knowledge growth should occur after graduating teacher education and beginning the teaching career. König (2013) has discussed that entering an internship, which in the German educational system happens in the second phase of studies, gives the possibility to supplement the conceptual GPK with practical strategies while understanding and analysing the knowledge recalled. This, in return, supports the development of GPK. However, the teacher education systems are somewhat different between Germany

and Estonia, as the German system provides pre-service teachers with an induction period of up to 2 years. In Estonia, internships are intertwined with theoretical studies, and after receiving their degree, pre-service teachers can instantly enter their teaching career.

Due to the differences in teacher education systems, the results of the current study indicated that those in-service teachers and teacher educators who possessed more practical experience had lower levels of GPK. More specifically, the longer the in-service teachers have worked, the lower their predicted GPK level. Also, the teacher educators who supervise pre-service teachers' internships and are therefore closely related to practical work at school showed lower levels of GPK. These results contrast with previous discussions that assume that in-school opportunities have a positive impact on GPK (König, 2013). GPK is not only the result of teacher education studies but also a resource for the teaching work ahead (König & Pflanzl, 2016). Also, one of the aims of measuring GPK in research has been to monitor the professional development of in-service teachers (Choy et al., 2013). If the test instrument is merely measuring theoretical knowledge that is not used in practice, the instrument does not fulfil this aim. In addition, measuring the theoretical aspect of GPK does not give a complete overview of the concept of GPK. Therefore, it is vital that GPK is studied in the context of teachers' everyday work, as this is the core of their professional skills (Ross & Chan, 2016).

Measuring knowledge with multiple-choice test items has strengths and weaknesses. The nature of testing is going beyond self-reported questionnaires, and therefore the results about the teacher's knowledge level are more trustworthy. However, the risk with multiple-choice items is that such a test may only assess participants' knowledge according to their ability to recall facts. As teachers' work is closely connected to practice, knowledge testing should also challenge their ability to apply practical and situation-based knowledge. One possibility to tackle GPK in a more natural context is to use video testing instead of multiple-choice questions testing, as also proposed, for example, by König and Pflanzl (2016). Based on their proposal, using videos in testing can integrate situation-specific interpretations, and therefore also knowledge from practice, with theoretical knowledge. König and Kramer (2016) investigated a novel instrument measuring the expertise of classroom management using video clips and a test. Compared to traditional GPK tests, the new approach added not only videos, but also open-response questions. The researchers concluded that video-based testing can add value to knowledge measurement as it is more directly connected to the real-life classroom. However, video-based assessment requires a very careful and precise scientific preparation, as well as resources (both technical resources and sufficient time). The scarcity of this type of assessment shows the complexity of applying video-based assessment on a larger scale. Therefore, another solution to tackle knowledge on a more analytical level can be adding open-ended questions to multiple-choice questions (König et al., 2011). Even though this solution requires fewer resources, applying it in a large-scale study is still challenging, as analysing open-ended questions

can be time-consuming and requires a very accurate and detailed coding key. This shows that assessing teachers' knowledge so that it would cover both theories and knowledge applied in practice is a complex task and holds several risks for different types of testing.

5.2 The representation of GPK dimensions in practice

In order to understand the application of the GPK dimensions in teaching practice, experienced and effective teachers described their use of this knowledge. When comparing the results with existing theoretical standpoints, several similarities and differences were found. The practicing teachers appeared to pay more attention to supporting the students from an emotional and interest-based point of view; however, in GPK literature, establishing rapport with students is only mentioned in relation to classroom management as a prerequisite for supporting students' attention (Gatbonton, 1999; Mullock, 2006; Torff & Sessions, 2005; Wong et al., 2008). Research in teaching and teacher education has shown that teachers value the relationships created in the classroom, as they support meaningful teaching and a caring environment (see e.g., Tirri & Ubani, 2013). In addition, motivational aspects were emphasized by teachers outside of the *affective-motivational dispositions* sub-dimension, showing how motivation is a more complex construct connected to other aspects of teaching rather than simply being a separate dimension. The literature suggests that affective-motivational dispositions mainly focus on motivational strategies and achievement motivation (Voss et al., 2011), while teachers specifically emphasized providing help and supporting students' interest as part of motivation. Being student-focused and emphasizing the importance of good communication were also reflected in teachers' descriptions of using knowledge from the *evaluation and diagnosis procedures* sub-dimension, while the literature focuses on different assessment types and criteria, including formative and summative assessments (König, 2013; Voss et al., 2011).

While teachers did describe most of the types of knowledge that are also described by different researchers, a shift in focus can be noticed. Researchers focus on knowledge from a more specific and detailed point of view: for example, designing the assessment tools (Choy et al., 2012, 2013) or knowing the theories of cognitive development stages (Liakopoulou, 2011). Teachers, however, described their knowledge on a more general level while paying more attention to students. This shift can be explained from two different perspectives. First, teachers' primary context of teaching is working with a group of students, which makes it understandable that relationships and emotional support play an important role in the teaching process. Second, when teachers exit teacher education and enter a job, specific and scientific knowledge that has been acquired during teacher education becomes less important compared to practical issues faced in the classroom (Meijer et al., 2002). Shalem (2014) has proposed that teachers possess two kinds of knowledge: theoretical knowledge and working

knowledge. This division could be one possible explanation for the results of this doctoral thesis. More specifically, the test instrument presented knowledge from educational theories learned during university courses, and studying GPK in the context of everyday practice showed more contextually specific knowledge (Shalem, 2014). Previous research has provided evidence that GPK predicts instructional practices related to supporting students in a heterogeneous group and managing the classroom (Depaepe & König, 2018). Similarly to the results of this study, both of these variables are student-centred and closely connected to building teacher-student relationships. Also, Atjonen et al. (2011) found that the teacher-student relationship (e.g., treating students equally, creating a peaceful learning environment) is a good example of GPK in practical teaching. These findings support the results of the current doctoral thesis, indicating that GPK in the practical field is more focused on students compared to scientific educational theories. Understanding how the empirical literature of GPK and practical application of GPK supplement each other can lead to higher quality teacher education in terms of teachers' knowledge (König, 2013) and also contributes to overcoming the gap between theory and practice (Hammerness, 2013; Korthagen et al., 2001).

Previous research has suggested that students' diversity is a separate dimension of GPK (e.g., Capel et al., 2009; Choy et al., 2012; Hoppo & Määttä, 2011). In the current study, students' diversity was seen as a coherent part of the overall GPK framework (Sonmark et al., 2017). This was also confirmed with the qualitative study, which shows how teachers pay attention to diversity and students' individuality throughout all GPK dimensions. As pointed out in the scientific literature, students' diversity includes knowledge of working with the whole group, differentiation and teaching methods (e.g., Blömeke et al., 2016; König, 2013) which are also considered part of the overall knowledge of teaching. Therefore, knowledge of diversity and special needs in teachers' practical work is not something separate but rather an integral part of teachers' knowledge.

The dimension of *data and research literacy* was first brought to GPK measuring through the TKS instrument. Even though the instrument analysis showed only one weak item in that dimension, the interpretation of teachers is entirely different from how it is assessed in TKS. While TKS paid more attention to specific knowledge of carrying out and interpreting research (Sonmark et al., 2017), teachers' main focus was on supporting students' knowledge of research literacy and to a lesser extent on research-based teaching. What is expressed by teachers is more in line with the literature in the area that defines teachers' research literacy from three viewpoints: 1) research-based teaching (Shank & Brown, 2013); 2) carrying out research on one's own teaching (Wilson et al., 2013); and 3) supporting students' research literacy (Evans, Waring, & Christodoulou, 2017). What is described in the TKS framework focuses more on statistical concepts and knowledge, which is the basis of understanding and using research; however, it is not at the core of teaching practice. Therefore, the research literacy that is used in teaching can differ greatly from what is assessed as GPK.

In summary, the investigation of the TKS test instrument for measuring GPK showed a unidimensional nature of GPK. Evidence from teachers' practice showed several connecting themes among the GPK dimensions. However, the TKS instrument appeared to be rather easy for the respondents, and the analysis showed that the easiest items were based on situation descriptions as opposed to theoretical concepts. When comparing differences among the background variables of the respondents, the results suggest that the test is measuring knowledge from literature rather than knowledge that is used in practice. This could indicate that the easy test items that were based on situation descriptions were merely constructed based on theoretical knowledge. Investigating the TKS framework among working teachers suggested that the GPK used in everyday teaching is more closely related to teachers' practical knowledge, which includes leading the group, paying attention to individual students and building relationships while supporting students' interest and motivation. This finding could have implications for future research by outlining how to measure GPK in order to capture the knowledge that teachers develop throughout their career and professional development in order to become more expert teachers.

5.3 Limitations and further research

The data on TKS was collected as a pilot study, hence the rather modest and uneven sample group sizes. However, this does not limit the investigation of a test instrument, and as the sample groups' characteristics were representative of the population, conclusions and further suggestions can be made. For future research, a probability sampling should be carried out. Another limitation is the sample being focused on one country, limiting conclusions on international applicability. An international perspective was not the focus of the current thesis, as GPK can be dependent on context and a country's educational policy (e.g., pre-service teacher education, opportunities for professional development of in-service teachers, etc.). However, the overall implications can still be informative and applicable to further international research.

In terms of research design, the GPK assessment was carried out as a cross-sectional study. Therefore, the results are limited to a single measurement point while comparing different population groups. Further research on specific curricula or professional development programs could use a longitudinal study design in order to strengthen the reliability of measuring teachers' knowledge gain.

As seen in the results, the TKS instrument has a bias toward assessing theoretical knowledge. This limits researchers' ability to learn about in-service teachers' GPK and make solid conclusions about their knowledge level. Additionally, it gives an advantage to teacher educators who use theoretical knowledge in their daily work. In future studies, including teachers' practical knowledge and conducting more research in the teaching context would increase the validity of the test instrument to assess the GPK that is used in practice. The qualitative

study also revealed that the novel dimension of *data and research literacy* is not considered by teachers the same way as it was intended by TKS; therefore, including research literacy as a dimension of GPK to be measured should be critically reviewed as it might be incorporated more in other contexts.

The video-stimulated recall study involved only seven teachers, which limits the ability to generalize the results. In addition, the video recordings were collected from one lesson per teacher. To overcome this limitation, the interview was developed as a semi-structured interview, giving an opportunity to ask the participants additional questions and guide them to think about their practice in general, regardless of the specific situations in the video recorded lesson. This approach can provide deeper insights about the GPK used in everyday practice, with a video recording supporting teachers' recollections.

5.4 Implications

The current doctoral thesis has several scientific and practical implications regarding research in the area of teachers' knowledge as well as in developing teacher education programs.

5.4.1 Scientific implications

Developing test instruments for measuring teachers' GPK has been a topical issue in research for the last decade (e.g., Choy et al., 2012; König et al., 2011). As there is limited information on test development and test instruments, the current thesis offers several suggestions for future research on GPK testing:

- 1) Teachers' GPK is a unidimensional construct that can be described within a framework of dimensions (König et al., 2011). Measuring GPK dimensions separately has lower reliability than measuring GPK as a unidimensional construct; however, dimensions can be used for describing the strengths and weaknesses of teachers' knowledge profiles.
- 2) Developing GPK test items solely based on scientific literature biases the assessment toward theoretical knowledge. However, as teachers' practical knowledge is an important addition to existing theories when successfully connected to research-based knowledge (Meijer, 2013), this should be taken into account in the item development stage. To do so, more research carried out in the context of teachers' action should be accounted for in the item content.
- 3) In order to study GPK in relation to other teaching-related variables (e.g., instructional quality), the test instrument must be developed so that the questions present a range of difficulty for respondents. In this study, the TKS instrument resulted in a test that was too easy for respondents to complete, and so it is necessary to develop more difficult items. More variety in the

difficulty of the questions also allows for more precise monitoring of in-service teachers' knowledge growth, as according to König (2014), the acquisition of GPK continues when entering the teaching job.

- 4) The TKS instrument has been shown to be curriculum-valid in the context of Estonian pre-service teachers regarding the conceptualization of the instrument. From a test development perspective, it is important to assess the knowledge that is expected to be acquired during teacher education (König, 2013).
- 5) The dimensions of GPK are connected through various themes, as suggested by the test instrument investigation and qualitative data from teachers. The current doctoral thesis suggests approaching the connecting themes through teachers' intentions (learning outcome, interest, wellbeing, motivation, attention) and teachers' activities (giving instructions, behavioural management, praise and support, time management, differentiation).
- 6) Teachers' research literacy was considered to be part of GPK in the TKS instrument (Sonmark et al., 2017), despite the lack of previous research in that area. The data from the context of teachers' practical work suggests that specific knowledge about research literacy is not used in the process of teaching. Instead, teachers mostly pay attention to supporting students' research literacy. It is not clear if this should be considered as part of the GPK dimension, as there is a lack of empirical evidence in the area.
- 7) Students' diversity has previously been referred to as a separate dimension of GPK (e.g., Capel et al., 2009; Choy et al., 2012; König, 2013). The results of this doctoral thesis suggest that teachers take students' diversity into account within all other GPK dimensions, indicating that knowledge about special needs and group heterogeneity is part of teachers' overall GPK.
- 8) Video-stimulated recall interviewing is a method that allows researchers to collect multifaceted data during the teaching process. It also gives them an opportunity to gain more profound insight into the nature of teachers' knowledge (e.g., the content of overlapping themes), which is a good addition to quantitative data collection methods.

5.4.2 Practical implications

- 1) TKS is a valid and reliable instrument that can be used for measuring pre-service teachers' GPK, as well as monitoring pre-service teachers' development throughout their curriculum. As König (2013) has stated, demonstrating the growth of GPK during teacher education studies can be evidence for an effective program.
- 2) Knowing about the nature and development of GPK is important for developing teacher education programs and opportunities for professional development. However, the subjects of teacher education are commonly separated from topics of GPK, and therefore, reaching conceptual coherence in the teacher education program is a challenge (Hammerness, 2006). Knowing the themes that connect different dimensions of GPK can give

information on how to build the teacher education program both structurally and conceptually.

- 3) Research literacy is a concept that is not always directly applied in teaching practice. Applying research-based teaching, researching one's own teaching and supporting students' research literacy might not be part of everyday teaching practice, however, these activities still possess an important role in teachers' professionalism. Additionally, research literacy is stated as an expectation in Estonian teaching standards. It may be beneficial to create more professional development activities for teachers and schools that support teachers' research literacy.

SUMMARY IN ESTONIAN

Õpetajate üldpedagoogilised teadmised: nende olemus, hindamine ja esindatus praktikas

Õpetajate teadmised on oluline faktor õpetamise kvaliteedis, mis on omakorda seotud õpilaste õpitulemustega (Grossman & McDonald, 2008). Õpetajakoolituse uurijad eristavad kolme peamist teadmiste kategooriat: ainealased teadmised, õppesisu pedagoogilised teadmised ning üldpedagoogilised teadmised (Baumert et al., 2010; König & Pflanzl, 2016; Shulman, 1986). Kui esimese kahe teadmiste kategooria raames on läbi viidud arvukaid uuringuid, siis õpetajate üldpedagoogilised teadmised on teadustöös saanud pigem vähem tähelepanu (König et al., 2011). Shulman (1987) järgi on üldpedagoogilised teadmised „üldpõhimõtted ja strateegiad klassi juhtimise ja korralduse kohta, õppeainest sõltumata“ (lk. 8). Shulmani (1987) esialgset definitsiooni on erinevad uurijad läbi aastakümnete täiendanud. Näiteks on definitsiooni täiendatud teadmistega õppijate ja õppimise, hindamise, haridusliku konteksti ja eesmärkide kohta (König et al., 2011). Hiljem on definitsioonis mainitud ka motivatsiooni ning spetsiifilisemalt tunni planeerimist ja diferentseeritud õpetamist (Lauermann & König, 2016). Üks hilisemaid definitsioone on kirjanduse ülevaate põhjal välja pakutud Guerriero (2017) poolt, leides, et õpetajate üldpedagoogilised teadmised on „õpetajate spetsialiseerunud teadmised, et luua ja hallata kõikide õpilaste jaoks efektiivseid õpetamise ja õppimise keskkondi, õppeainest sõltumata“ (lk. 80).

Lisaks definitsioonile eristatakse uuringutes ka üldpedagoogiliste teadmiste erinevaid dimensioone. Kui 1990ndatel keskenduti pigem nende dimensioonide leidmisele kvalitatiivsete uurimuste kaudu, siis hiljem on hakatud kvantitatiivsete uurimuste raames juba varasemalt välja töötatud dimensioone testima. Üks levinumaid selliseid teste on TEDS-M (*Teacher Education and Development Study in Mathematics*; nt. König et al., 2011), mille abil on mitmetes uuringutes õpetajate teadmisi mõõdetud. TEDS-M raamistiku järgi jagunevad üldpedagoogiliste teadmiste dimensioonid järgmiselt: 1) struktuur (tunni planeerimine ja eesmärgid); 2) motivatsioon/klassi juhtimine; 3) kohanemisvõime (diferentseerimine, õpetamise meetodid); 4) hindamine. OECD (*Organisation for Economic Co-operation and Development*) CERI (*Centre for Educational Research and Innovation*) arendas aga TEDS-M testi edasi ning kirjanduse analüüsi põhjal leiti, et õpetajate üldpedagoogilised teadmised koosnevad kolmest peakategooriast ja kuuest alakategooriast: õpetamisprotsess (alakategooriad: õpetamise meetodid ja tunni planeerimine ning klassi juhtimine), õppimisprotsess (alakategooriad: õppimine ja areng ning emotsionaal-motivatsioonilised seadumused), hindamine (alakategooriad: hindamise printsiibid ja protseduurid ning uurimistööalane kirjaoskus) (Sonmark et al., 2017). Kui viimane alakategooria – uurimistööalane kirjaoskus – on õpetajate üldpedagoogiliste teadmiste kontekstis pigem uus, siis võrreldes OECD poolt väljatooduga on varasemalt

kirjanduses sarnaselt teistele aladimensioonidele eristatud ka õpilaste mitmekesisuse dimensiooni (nt Capel et al., 2009; Haplo & Määttä, 2011).

Üldpedagoogiliste teadmiste mõõtmiseks on kasutatud nii enesekohaseid küsimustikke kui ka teadmiste teste. Kui küsimustikes märgivad vastajad iseenda tajutud teadmiste taseme, siis testides hinnatakse teadmisi selle jaoks välja töötatud küsimuste kaudu. TEDS-M testi abil on leitud, et neljadimensioonilise (struktuur, motivatsioon/klassi juhtimine, kohanemisvõime ja hindamine) mudeli usaldusväärsus on madalam (.64 kuni .72) võrreldes ühedimensioonilise mudeliga (.78) (König et al., 2011). Lisaks sellele leiti TEDS-M testi abil, et õpetajakoolituse üliõpilaste üldpedagoogilised teadmised kasvavad õpetajakoolituse õpingute jooksul ning et ühedimensiooniline üldpedagoogiliste teadmiste mudel on usaldusväärsem mitmedimensioonilisest mudelist (König, 2013). König jt. (2014) tõid oma tulemustes ka välja, et õpetajate üldpedagoogilised teadmised jätkavad kasvamist töötavate õpetajate seas vastavalt töötatud aastatele ning Klemenz, König ja Schaper (2019) lisasid, et töötavate õpetajate täiendus-koolitused mõjutavad nende üldpedagoogilisi teadmisi.

Viimastel aastakümnetel on rõhutatud, et õpetajate professionaalne areng ja teadmised on oluline alus efektiivseks õpetamiseks (Baumert et al., 2010), mistõttu on korduvalt välja toodud ka üldpedagoogiliste teadmiste mõõtmise vajalikkus ja olulisus (König et al., 2020). Selleks on vajalik välja töötada valideeritud instrumente, mis hindaksid õpetamispraktikaga seotud üldpedagoogilisi teadmisi. Vaatamata eelnimetatule on üldpedagoogiliste teadmiste empiiriline hindamine pigem uus suund, mida on püüdnud lahendada vaid üksikud uurijad (Depaepe & König, 2018). Eelkirjutatust tulenevalt on käesoleva doktoritöö eesmärgiks analüüsida ühte õpetajate üldpedagoogiliste teadmiste mõõtmiseks välja arendatud uurimisinstrumenti ning saada ülevaade nendest üldpedagoogilistest teadmistest, mida kasutatakse igapäevases õpetamispraktikas. Lähtuvalt eesmärgist on püstitatud kolm uurimisküsimust:

1. Milline on üldpedagoogiliste teadmiste mõõtmiseks välja arendatud instrumendi ja selle küsimuste kvaliteet?
2. Millised erinevused esinevad Eesti õpetajakoolituse üliõpilaste, töötavate õpetajate ja õpetajakoolituse õppejõudude üldpedagoogilistes teadmistes ning millised taustaandmed on seotud üldpedagoogiliste teadmistega?
3. Milliseid üldpedagoogiliste teadmiste dimensioone kasutatakse igapäevases õpetamispraktikas ning kuidas on need dimensioonid omavahel seotud (Eesti kontekstis)?

Andmete kogumiseks viidi läbi kaks uurimust. Esimeses uurimuses osalesid 170 õpetajakoolituse üliõpilast, 175 töötavat õpetajat ning 48 õpetajakoolituse õppejõudu ning üldpedagoogiliste teadmiste hindamiseks kasutati *Teacher Knowledge Survey* (TKS; Sonmark et al., 2017) instrumenti. Andmeid analüüsiti esimese ja teise uurimisküsimuse raames peamiselt kvantitatiivselt (1PL *Item Response Theory*, ANOVA, hierarhiline lineaarregressioon), kuid esimesele uurimisküsimusele vastamiseks kasutati testiküsimuste detailsemaks analüüsi-

miseks ka induktiivset sisuanalüüsi. Teises uurimuses osales seitse tunnustatud ja kogenud õpetajat ning andmeid koguti videoga toetatud meenutusintervjuu kaudu. Kolmandale uurimisküsimusele vastamiseks viidi läbi deduktiivne ja induktiivne sisuanalüüs.

Esimese uurimisküsimuse tulemused näitavad, et üldpedagoogilisi teadmisi kirjeldab kõige paremini ühedimensiooniline mudel, nagu on leitud ka varasemates uurimustes (nt König, 2013; König et al., 2011, 2016). Samas on varasemad uuringud näidanud, et ühedimensioonilises mudelis on igal dimensioonil võrdne roll teadmiste kogumi kujunemisel (König et al., 2011; Voss et al., 2011), mistõttu võib olla dimensioonide eristamine ja kirjeldamine abiks üldpedagoogiliste teadmiste spetsiifiliste teemade defineerimisel ning vastajate tugevuste ja nõrkuste leidmisel (König et al., 2011). TKS instrumendi kohta leiti veel, et test on vastajatele pigem lihtne ning küsimused saab jaotada kolme alarühma: 1) lihtsad küsimused, mis tuginevad situatsiooni kirjeldustele; 2) keskmise raskusastmega küsimused, kus situatsioonikirjeldused on seotud teoreetiliste teadmistega; ning 3) rasked küsimused, mis põhinevad teoreetilistel teadmistel. Olles teadlik küsimuste erinevatest tasemetest, on võimalik testiinstrumenti edasi arendada nii, et selle abil oleks võimalik vastajaid paremini diferentseerida ja seeläbi koguda empiirilisi andmeid üldpedagoogiliste teadmiste kohta.

Teise uurimisküsimuse raames selgus, et Eesti õpetajakoolituse üliõpilaste ja töötavate õpetajate teadmised on pigem sarnasel tasemel, kuid õpetajakoolituse õppejõud omavad võrreldes nende kahe rühmaga kõrgemaid teadmisi. Kui õpetajakoolituse üliõpilaste teadmised kasvavad vastavalt õpetajakoolituse tasemele, nagu on leidnud ka König (2013), siis praktilal osalemise tulemusena nende teadmised pigem langevad. Ka töötavate õpetajate seas näitasid tulemused, et mida rohkem aastaid õpetaja on töötanud, seda madalamad on nende üldpedagoogilised teadmised. See tulemus on vastuolus varasemate uurimustega, mille järgi praktiliste kogemuste tulemusel õpetajate üldpedagoogiliste teadmiste kasv jätkub peale õpetajakoolituse lõpetamist (nt Choy et al., 2013; König, 2013). Lisaks sellele näitavad tulemused ka õpetajakoolituse õppejõudude osas, et üliõpilaste praktikat juhendades võivad üldpedagoogilised teadmised pigem langeda. Sellest tulenevalt võib oletada, et TKS testi kontseptsioon on pigem kooskõlas õpetajakoolituse õppekavade ülesehitusega, näidates teoreetiliste teadmiste süstemaatilist kasvu läbi õppe taseme (König, 2013). Need tulemused viitavad TKS testi teoreetilisele olemusele, jättes tähelepanuta praktilise töö käigus omandatavad teadmised.

Lähtudes teise uurimisküsimuste tulemustest, oli oluline uurida üldpedagoogiliste teadmiste kasutamist praktilises õpetamistöös. Videoga toetatud meenutusintervjuu tulemused näitavad, et võrreldes teoreetilise kirjandusega, on praktikas kasutatud üldpedagoogiliste teadmiste olemus rohkem keskendunud õpilastega suhete loomisele ning õpilaste toetamisele. Seda võib seletada õpetajate töö olemusega, kus spetsiifiline ja teaduslik teadmine muutub õpetajatöös esinevate kiirete praktiliste probleemide lahendamisel vähem tähtsamaks (Meijer et al., 2002). Lisaks sellele on Depaepe ja König (2018) leidnud, et üldpeda-

googilised teadmised prognoosivad just selliseid õpetamispraktikaid, mis on seotud õpilaste toetamisega heterogeensetes rühmades ning klassi juhtimisega. Kolmanda uurimisküsimuse raames leiti ka, et üldpedagoogiliste teadmiste dimensioonide vahel on mitmeid ühiseid tunnuseid, mis toetab varasemat tulemust üldpedagoogiliste teadmiste ühedimensioonilisuse kohta. Ühised tunnused jagunesid Ajzen (1985) plaanitud käitumise teooria järgi kavatsusteks ning tegevusteks. Kavatsuste alla kuuluvad tunnusjooned väljendavad seda, kuidas õpetaja peamine fookus oma teadmiste rakendamisel on toetada õpilast ehk õpilase õpitulemusi, huvi, heaolu, motivatsiooni ning tähelepanu. Kavatsusi rakendatakse tegevuste kaudu, täpsemalt läbi juhiste andmise, käitumise juhtimise, kiitmise ja toetamise, ajaplaneerimise ning diferentseerimise. Meenutusintervjuudest selgus ka, et oma praktilises õpetajatöös kasutavad õpetajad uurimistööalaseid teadmisi pigem erinevalt võrreldes sellega, mida mõõdab TKS instrument. Sellest tulenevalt vajavad uurimistööalased teadmised rohkem uurimist, et mõista nende potentsiaalset olemust ja rolli õpetajate üldpedagoogilistes teadmistes.

Kirjeldatud tulemuste põhjal saab anda soovitusi nii edasiseks uurimistööks üldpedagoogiliste teadmiste valdkonnas kui ka üldpedagoogiliste teadmiste arendamiseks õpetajakoolituses. Üldpedagoogiliste teadmiste ja teiste õpetamisega seotud tunnuste seoste uurimiseks on edaspidi soovitav kasutada ühedimensioonilist mudelit. Testi küsimuste ülesehitamisel tuleks aga olemasolevad teooriad seostada teaduspõhise praktilise teadmisega (Meijer, 2013), eesmärgiga mõõta neid teadmisi, mis omavad praktikas kõige olulisemat rolli. TKS instrumenti saab kasutada õpetajakoolituse üliõpilaste teadmiste arengu kohta informatsiooni kogumiseks, et veenduda õpetajakoolituse õppekava efektiivsuses (König, 2013). Olles teadlik üldpedagoogiliste teadmiste dimensioonide omavahelisest kattuvusest, on võimalik paremini korraldada õpetajakoolituse õpingud, et erinevad õppeained täiendaks teineteist ning seeläbi oleks paremini tagatud ka õpetajakoolituse kontseptuaalne sidusus (Hammerness, 2006).

APPENDICES

Appendix 1. Observation protocol used in Study II.

How would you describe using general pedagogical knowledge in your everyday work? Which kind of knowledge did you use in the observed lesson?

	Teaching methods and lesson planning	Classroom management	Learning and development	Affective-motivational dispositions	Evaluation and diagnosis procedures	Data and research literacy
	structuring learning objectives, lesson, units of curriculum and assessment, as well as applying difference methods in order to facilitate pupils' understanding of the learning content.	managing several classroom events simultaneously, lesson timing, giving instructions and keeping pupils' attention	cognitive learning processes, learning strategies, the role of prior knowledge, memory and information processing, etc.	motivational learning processes, strategies for motivating a pupil or group of pupils	formative and summative assessment, the relationship between assessment and student motivation, quality of assessment	interpreting, evaluating and using research in order to enhance teaching and learning.
..... :	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Keywords, short comment:

..... :	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Keywords, short comment:						

I would like to add new categories of knowledge which have not been described in the previous table:

..... :	KNOWLEDGE CATEGORY:
Keywords, short comment:	
..... :	KNOWLEDGE CATEGORY:
Keywords, short comment:	

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