# USING NEW TECHNOLOGY AND STIMULATING STUDENTS' HIGHER-ORDER THINKING: A STUDY ON PRIMARY SCHOOL TEACHERS' ATTITUDES

FRANCES WIJNEN

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# 1

# General introduction

*Caroline (34) is very happy today. She had made an assignment for her students, and they had been so enthusiastic about it. The students had to learn about the habitat of different animals. Instead of giving them books or letting them use Google for the necessary information, she made an assignment where the whole class together had to design a zoo. She made groups of students and each group was responsible for designing a part of the zoo, such as the aquarium, the desert, the plains etc. In addition, she had borrowed some Google cardboards (a very simple form of virtual reality) and smartphones, so that each group had a Google cardboard and phone. They could use the apps Google earth and Google expeditions to 'see' the actual habitats of the animals in 4D with the cardboard. They could use what they learned to design the habitats for the zoo. Even Tom, who was usually hard to motivate in regular lessons had been very enthusiastic about this assignment. He took on the role of leader in the group and together they created the aquarium. After exploring different places of the ocean through the Google cardboard they became interested in the coral reefs and decided to try and design a reef aquarium for the zoo. After looking for information on corals they learned that corals need sunlight. Therefore, they designed an aquarium with a glass roof so that the sun could shine through the roof. Caroline felt proud of her students for coming up with such an idea. At the end of the day, Tom even came to Caroline asking whether they could continue working on the zoo the next day.*

## Problem statement

In the example above, Caroline stimulates her students to engage in higher-order thinking. To design the zoo, the students must come up with ideas (e.g., think creatively) and evaluate those ideas (e.g., think critically) to solve problems (e.g., making sure the corals get enough sunlight). Higher-order thinking skills, such as critical thinking, creative thinking and problem solving are regarded as crucial for students to develop to be able to deal with complex problems and dilemma's that people encounter in life (Conklin, 2012; Driana, & Ernawati, 2019). Furthermore, students may actively construct knowledge and engage in meaningful learning when they become involved in higher-order thinking (Anderson et al., 2001).

Since it cannot be assumed that students will automatically become creative and analytical thinkers, teachers are expected to stimulate the development of higher-order thinking skills in their students (Elder, 2003; Schulz & FitzPatrick, 2016). This means that teachers should offer assignments or questions that require students to engage in complex cognitive skills (e.g., analysing, evaluating, creating) to find a solution, take a decision, or make a prediction, judgement or product (King et al., 1998). However, teachers rarely aim to explicitly stimulate students' higher-order thinking (e.g., Collins, 2014; Driana, & Ernawati, 2019) and researchers have expressed concern about the strong emphasis on mere recall and understanding of information in education (e.g., Schulz & Fitzpatrick, 2016; Zohar, 2004).

Stimulating higher-order thinking can be done in different ways, such as answering teacher and/or student generated questions, reflecting on dilemma's and coming up with self-generated solutions for a problem. Furthermore, letting students work together in small groups and stimulating activities, such as group discussion, peer tutoring, and cooperative learning, are effective methods for engaging students in higher-order thinking (King et al., 1998; Singh et al., 2018).

Research shows that technology can be used as a tool to support students' learning, including stimulating their higher-order thinking skills (Backfish et al., 2020; Mayer, 2019). The affordances of technologies, such as in the example at the beginning of this introduction, provide opportunities to enrich the learning environment (Ottenbreit-Leftwich et al., 2018). For example, by enhancing students' (online) collaborative skills (e.g., via social media), or by simulating authentic problems or (aspects of) the physical world (e.g., via games, augmented and virtual reality) in which skills, such as exploring, planning, designing, and creating solutions, might be practiced. Technologies such as augmented reality, virtual reality, and games have been found to advance students' higher-order thinking, compared to teaching methods that do not include such technologies (Araiza-Alba et al., 2021; Chiang et al., 2014; Passig et al., 2016; Tangkui & Keong, 2020).

We use the term *new technology* for technologies that are considered new for the teachers in our studies. In the Dutch context (where our studies were conducted) teachers do not often use the technologies mentioned above (Smeets, 2020; Voogt et al., 2016) and we therefore expect that most teachers have little experience with these technologies in their teaching. Using technologies such as virtual reality and games in teaching would therefore be *new* for many Dutch primary school teachers.

Research shows that the majority of primary school teachers use technology mainly to stimulate *lower-order* thinking, such as using technology to test students' recall of factual knowledge about a specific topic (De Aldama & Pozo, 2016; Ertmer et al., 2015; Voogt et al., 2016; Smeets & Van der Horst, 2018). Such technology use reflects an emphasis on knowledge transfer and reproduction of content, rather than using technology to stimulate children's own analysis, knowledge construction, or problem solving.

To support primary school teachers in their use of technology to stimulate higher-order thinking, it is important that we gain an understanding of teachers' *attitudes* towards using technology *and* towards stimulating higher-order thinking. The importance of attitude has been emphasized in many studies (e.g., Vögel & Wanke, 2016; Howe & Krosnick, 2017). Attitude impacts a persons' intention and behaviour and the way a person processes information regarding the attitude-object (Vögel & Wanke, 2016). However, there is little research on teachers' attitudes towards stimulating higher-order thinking, especially at the primary school level

(Schulz & FitzPatrick, 2016) and we know little about teachers' attitudes towards using technology to stimulate higher-order thinking. In this dissertation, we aim to fill this void in research by studying pre- and in-service primary school teachers' attitudes towards using new technology in teaching and towards stimulating higher-order thinking in students.

## Key concepts

### *Attitude*

There are many definitions of the construct attitude. Some definitions describe attitude as emotions that a person can experience, such as pleasure (e.g., Teo, 2015), whereas other definitions describe attitudes as beliefs related to a specific subject or behaviour that a person may hold (e.g., Baek et al., 2017). To define attitude in this dissertation we went back to one of the core theories on attitude, the Theory of Planned Behaviour (Ajzen, 1991; 2001). We chose to use the TPB because it has proven to be a valuable framework that describes important dimensions that can impact a person's intended and actual behaviour in various contexts (for a meta-analytic review on the TPB, see Armitage & Conner, 2001).

According to the TPB, human behaviour is guided by three types of subjective perceptions: (1) perceptions about certain attributes of the behaviour (beliefs or opinions, which can be cognitive and affective), (2) beliefs about the normative expectations of others (normative beliefs), and (3) beliefs about the extent to which a person may or may not be hindered by internal or external factors to enact a behaviour (control beliefs). According to Ajzen (2001), "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). An attitude-object is the entity about which an attitudinal evaluation is made (Ajzen, 1991, 2001) and is usually a specific behaviour.

Using this conception of attitude, we view attitude as an umbrella term, consisting of three dimensions that are based on the three subjective perceptions, which together form a person's attitude towards a particular behaviour. These dimensions are comprised of factors that are specific for each behaviour. The first dimension, *perceptions of behavioural attributes,* represents beliefs and feelings a person associates with the specific behaviour, in this case, teachers' (intended) use of technology and stimulation of students' higher-order thinking, respectively. The second dimension, *perceptions of social norms*, represents a person's perception of the social acceptability of the behaviour. The third dimension, *perceptions of behavioural control*, represents a person's perception of the level of control he/she has as far as performing the behaviour. These perceptions can refer to external factors (e.g., availability of resources or time) that impact a persons' perception of control, or internal factors, such as perceived capability of performing the behaviour, which is frequently defined as “self-efficacy”, based on Bandura’s concept (Ajzen, 2002; Armitage & Conner, 2001).

A person’s views regarding each of the factors that comprise these three dimensions may impact a person’s intention to perform or not perform a specific behaviour (Ajzen, 1991). It is assumed that the stronger an intention, the more likely it is that the person will enact the behaviour (Ajzen, 1991).

In this dissertation, we chose to study teachers’ attitudes towards using new technology and towards stimulating higher-order thinking separately, for two reasons. First, teachers may have *differing attitudes* towards new technology use and stimulating higher-order thinking. For example, a teacher might have a positive attitude towards new technology use, but a negative attitude towards stimulating higher-order thinking, with or without the use of technology. Second, it is possible that *different factors* underlie these teacher attitudes. For example, Zohar et al. (2001) found that most teachers believe that higher-order thinking is more suitable for high-achieving students than for low-achieving students. However, a similar belief has not come up in research on teachers’ attitudes towards using (new) technology.

*New technology use*

In this dissertation, we describe technology as hardware and software that teachers can use to support and/or enrich their teaching practices. Teachers use different forms of technology in their teaching, such as computers and digital whiteboards (Smeets & Van der Horst, 2018). However, the implementation of technologies such as virtual reality, educational robots, and 3D-printers is still not very common (Fraillon et al., 2018) even though these technologies provide opportunities to enhance students learning (Backfish et al., 2020), including higher-order thinking (Airaiza-Alba et al., 2021). To gain insight into teachers’ attitudes towards using technologies that are still not very common, we chose to study primary teachers’ attitudes towards using *new* technology in our second (Chapter 3) and fourth study (Chapter 5).

The term *new* technology may have a different meaning for different people. What is ‘new’ is dependent upon what technology is available for teachers to use (context), whether a teacher has used specific technologies before (experience), and whether a teacher is aware of the affordances that specific technologies offer to support students learning. To define *new* technology, we decided to focus on the use of technology to enhance teachers’ teaching practices and to provide examples of technologies that are currently hardly used by Dutch teachers (the context in which the studies in this dissertation took place). Several studies in the Netherlands (Smeets, 2020; Voogt, et al., 2016) showed that teachers mostly use the interactive whiteboard and hardly use other technologies (e.g., robots, virtual reality) to enhance their teaching practices. We used the following explanation of new technology in questionnaires and interviews for the teachers participating in the studies of this dissertation: "New technology refers to hardware and software that teachers can use to support and/or enrich their teaching practices. Some examples of hardware are: smartphones, tablets, 3D printers and educational robots (BeeBot, DASH). Software examples are: simulation software, design software, programming software and video-editing software."

### *Higher-order thinking*

There are many descriptions of higher-order thinking (Lewis & Smith, 1993). Labels such as critical thinking, problem solving, creative thinking, reasoning, metacognition, or reflective thinking are all part of 'higher-order thinking'. The well-known cognitive taxonomy of Benjamin Bloom can be used to develop educational objectives to stimulate students' thinking on different levels. In 2001, Anderson et al., presented a revised version of Bloom's taxonomy in which the thinking skills of remembering, understanding and applying were regarded as lower-order thinking skills and analysing, evaluating, and creating were regarded as higher-order thinking skills (Anderson et al., 2001). Teachers may use Blooms' taxonomy to design assignments and/or questions depending on the level of thinking they aim to stimulate in their students.

For example, if the goal is that a student remembers the meaning of different road signs, a teacher may present different road signs and ask students to explain their meaning. However, a teacher can also use a different approach. The teacher can give students an assignment where there is a specific traffic problem and ask students to solve this traffic problem. For example, there might be a crossroad where there is a traffic jam every morning because it is too busy. What could be done to make sure there is less delay on the crossroad (a roundabout, traffic lights, broadening the road, designing another route to the highway etc.). To come up with a solution for this problem, students need to gain insight into traffic situations and come up with and evaluate possible solutions. The first example illustrates a lower-order thinking assignment, while the second example illustrates a higher-order thinking assignment.

King et al., (1998) describe higher-order thinking as a set of skills that

> "… include critical, logical, reflective, metacognitive, and creative thinking.
> These skills are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful application of the skills results in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continued growth in these and other intellectual skills". (p. 1)

Based on the definitions of King et al., (1998) and Bloom's revised taxonomy (Anderson et al., 2001) we define *stimulating* higher-order thinking (since that is the 'attitude object' in our studies), as follows: offering assignments, questions, problems or dilemmas where students need to use complex cognitive skills (i.e., analysing, evaluating and creating) in order to find a solution or make a decision, prediction, judgement or product.

## Research on teachers' attitudes towards technology use

For the past decades much research has been done on (attitudinal) factors that impact teachers' use of technology in education (e.g., Petko et al., 2018; Scherer & Teo, 2019; Van der Linde et al., 2014). This research led to the development (or expansion) of several models and frameworks that describe (attitudinal) factors that may impact teachers' use of technology in their teaching, such as the Technology Acceptance Model (TAM; Davis, 1989) and its successors TAM 2 (Venkatesh & Davis, 2000) and TAM 3 (Venkatesh & Bala, 2008), the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003), the Integrative Model of Behaviour Prediction (IMBP), which was used by Kreijns et al., 2013 in the context of teachers technology use, and the Technological, Pedagogical, and Content Knowledge framework (TPACK; Mishra & Koehler, 2006). However, these models differ in the description and number of factors, which makes it difficult to estimate whether all relevant factors are described (for a more in-depth description of the models, see Niederhauser & Lindstrom, 2018).

Furthermore, research on teachers' attitudes towards using technology is hindered by several theoretical and methodological issues. First, the definition of attitude has varied between studies or is not clearly described. Some studies lack a definition of attitude (e.g., Steiner & Mendelovitch, 2017), do not explain the underlying subcomponents of attitude that are measured (e.g., Sami Konca et al., 2016), or do not distinguish between attitude and related constructs, such as interest or motivation (e.g., Meishar-Tal & Ronen, 2016). Second, different terms are used to refer to the same attitudinal factors. For example, teachers' self-perceived capability to use technology in teaching is referred to as: self-efficacy (e.g., Jeong & Kim, 2017), ICT competences (e.g., Vanderlinde et al., 2014), and perceived knowledge and skills (e.g., Heitink et al., 2016). Third, the attitude-object is not always clearly defined. For example, researchers sometimes measure teachers' attitudes towards technology use *in general* (e.g., Christensen & Knezek, 2009) rather than their attitudes towards using technology *in teaching*.

In order to address these theoretical and methodological issues, we conducted a literature review (Chapter 2) to develop an overview of attitudinal factors that make up primary school teachers' attitudes towards using technology in teaching. Research shows that technologies such as virtual reality, educational robots, and

3D-printers are often new for teachers and not often used (Fraillon et al., 2018) even though these technologies provide opportunities to enhance students learning (Backfish et al., 2020). In our second and fourth study we chose to study primary school teachers' attitudes towards using *new* technology (see also section on new technology use).



## Research on teachers' attitudes towards stimulating higher-order thinking

It is interesting that, despite the commonly held idea that stimulating higher-order thinking skills in students is important, there is little research on teachers' *attitudes* towards teaching behaviours that promote higher-order thinking. Especially when it concerns research on *primary school* teachers' attitudes (Schulz & FitzPatrick, 2016). As a consequence, we know little about how teachers perceive the stimulation of higher-order thinking in their students. Do they think it is important? Do they feel capable to do this?

Research on higher-order thinking has focused on teaching strategies that teachers (may) use to engage students in higher-order thinking, such as creating an open atmosphere in the classroom, encouraging students to ask questions, or giving assignments that challenge students to think on a higher level (e.g., Abrami et al., 2015; Miri et al., 2007; Schoevers et al., 2019). Furthermore, there is some research that focuses on teachers' attitudes towards one or more higher-order thinking skills (e.g., Newton & Beverton, 2012). For example, a teacher may have a positive attitude towards creativity or creative students (e.g., Bereczki & Kárpáti, 2018). Although this research helps us understand how teachers view (students who use) such skills, it does not provide insight into how teachers view *stimulating* higher-order thinking.

In the literature that is available on teachers' attitudes towards stimulating higher-order thinking, we see that, due to the different descriptions of higher-order thinking the attitude-object varies between studies. Furthermore, in the literature on teachers' attitudes towards stimulating higher-order thinking, different terms are used to refer to the same underlying attitudinal factors. For example, Tornero (2017) uses the term 'perceived ability', whereas Baysal et al., (2010) use the term 'self-efficacy' to refer to teachers' perceptions about their capability to teach higher-order thinking.

## The current thesis

In this dissertation, we used the above-described perspectives on attitude, new technology use and stimulating higher-order thinking to gain insight into pre- and in-service primary school teachers' attitudes towards using new technology and stimulating higher-order thinking. The research question that we aimed to answer is: What are primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students. Although our initial goal was to study primary school teachers' attitudes towards using new technology *for* stimulating higher-order thinking we decided, for reasons described above, to study these teacher attitudes separately in the first three studies (see Chapters 2 to 4).

In the first study of this dissertation, we set out to explore the literature on primary school teachers' attitudes towards technology use and towards stimulating higher-order thinking. In this literature review, we conducted two reviews to (1) identify factors that make up teachers' attitudes towards using technology and (2) identify factors that make up teachers' attitudes towards stimulating higher-order thinking. In this literature review, we did not focus on *new* technology, but evaluated literature about technology in general, whether that be a specific form of technology such as games or robots, or broader descriptions of technology such as ICT or digital learning materials. We chose this approach, because the meaning of the term new technology is, as described above, dependent upon a teachers' experience and context. We did not want to determine beforehand, what should be considered new technology. Furthermore, because we included literature describing different types of technology, we assume that the identified factors are also relevant when studying teachers' attitudes towards using new technology.

In addition to the identification of attitudinal factors, we evaluated what is known about the relationship between the identified attitudinal factors and teachers' intended and/or actual technology use and teachers' intention and/or actual behaviour to engage students in higher-order thinking. This gave us insight into the factors that are important to consider if we want to study teachers' attitude towards using (new) technology and towards stimulating students' higher-order thinking.

Based on the two theoretical frameworks that resulted from our literature review, we developed and validated two measurements instruments (questionnaires) that allow us to measure primary school Teachers' Attitudes towards using New Technology (TANT questionnaire; Chapter 3) and primary school teachers' attitudes towards Stimulating Higher-Order Thinking in students (SHOT questionnaire; Chapter 4). We had several reasons to develop a new instrument for measuring pre- and in-service primary school teachers' attitude towards new technology. First, to our knowledge there is no instrument that can be used to measure pre- and in-service primary school teachers' attitudes towards using *new* technology. Furthermore, the theoretical issues described above, such as differing definitions of attitude, and not having a clear description of the attitude-object has had an impact on how teachers' attitude towards technology use is measured. Therefore, based on already existing instruments we developed and evaluated the validity of the TANT questionnaire. In addition to measures of attitude, we included a scale to measure teachers self-reported new technology use to explore relations between attitude and teachers' actual new technology use.

Since, to our knowledge, no instrument exists that can be used to measure pre- and in-service primary school teachers' attitude towards stimulating higher-order thinking, we developed and evaluated the validity of a new measurement instrument, the SHOT questionnaire (Chapter 4). In addition, to measures of attitude, we also included measures of teachers self-reported behaviour related to stimulating higher-order thinking in the SHOT questionnaire. This allowed us to explore relations between teachers' attitude and teaching behaviour aimed at stimulating higher-order thinking.

In our last study (Chapter 5), we used the same dataset as we used in chapter 3 and 4 to identify teacher profiles based on teachers' attitude towards using new technology and towards stimulating higher-order thinking. Identifying teacher profiles, could give us a better understanding of how different teachers view the use of new technology and stimulating higher-order thinking in students and to what extent this impacts their teaching. This might help us understand whether, how and why teachers use new technology and/or stimulate students' higher-order thinking. Furthermore, identification of such profiles could provide insight in the needs for teacher support for different groups of teachers, which may allow us to develop teacher-tailored professionalization that fit these needs.

In sum, this dissertation is made up by four separate studies. Each study is self-contained, meaning that each study has its own theoretical introduction and discussion of results. The general introduction and overall discussion are presented as separate chapters in this dissertation.

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# 2

# Primary school teachers' attitudes towards technology use and stimulating higher-order thinking in students: A review of the literature

This chapter is based on: Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2021). Primary school teachers' attitudes toward technology use and stimulating higher-order thinking in students: A review of the literature. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2021.1991864

## Abstract

In order to gain insight into the factors that make up primary school teachers' attitude towards using technology for stimulating higher-order thinking, we conducted two separate literature reviews on teachers' attitudes towards (1) using technology (78 articles) and (2) stimulating higher-order thinking in students (18 articles). To structure the potential underlying constructs constituting teachers' attitudes in these two contexts, we used the Theory of Planned Behaviour. We identified nine factors related to primary school teachers' attitudes towards using technology in their teaching and four factors related to primary school teachers' attitudes towards stimulating higher-order thinking. Furthermore, we found that it was not always possible to establish the impact of each factor on teachers' intended or actual use of technology and behaviours stimulating higher-order thinking, respectively.

## Introduction

Many researchers, educators and policymakers agree that learners need to learn to think critically, to be creative and to be able to solve complex problems (Voogt et al., 2013). Such higher-order thinking skills are regarded as crucial, even at the primary school level, to be able to deal with the complex problems, dilemmas and questions that young people may face later in life and are therefore mentioned in many models concerning 21st-century learning (Voogt & Pareja Roblin, 2012; World Economic Forum, 2016). Furthermore, students who engage in higher-order thinking actively construct knowledge (Anderson et al., 2001). As a consequence, primary school teachers are expected to stimulate children in the development of higher-order thinking skills. This means that teachers should offer assignments in which students use complex cognitive skills (e.g., analysing, evaluating, creating) in order to find a solution or make a decision, prediction, judgement or product (King et al., 1998).

Researchers have argued that technology can be used to support constructivist teaching approaches that stimulate students to engage in higher-order thinking (Hopson et al., 2001; International Society for Technology in Education, 2021), for example, through games that challenge learners to explore, plan and create new things or by using virtual reality to let students practice skills in different (virtual) contexts. However, research has shown that although some primary school teachers do stimulate higher-order thinking in students, with or without the help of technology (Al-Nouh et al., 2014), the majority of primary school teachers use technology primarily to stimulate *lower-order* thinking, for example, to test students' recall of factual knowledge about a specific topic (Ertmer et al., 2015; Voogt et al., 2016). Such use reflects an emphasis on knowledge transfer and reproduction of content, rather than using technology to stimulate children's own analysis, knowledge construction, or problem solving.

Previous work has shown that teachers' attitude towards using technology and their beliefs about "good" teaching practices affect whether and how they use technology (e.g., Ertmer et al., 2015; Ottenbreit-Leftwich et al., 2018). For example, a recent study by Bowman et al. (2020) found that teachers' beliefs about the value of technology for learning significantly affected their technology integration practices in assignments aimed at both lower-order and higher-order thinking. However, little is known about teachers' attitude towards using technology *for stimulating higher-order thinking*. In order to gain insight into this particular teacher attitude, we reviewed the literature on factors that may affect teachers' attitudes towards using technology and towards stimulating higher-order thinking.

## The present study

Our original intent was to identify factors that make up primary school teachers' attitude towards using technology for stimulating higher-order thinking and to explore to what extent these factors influence teachers' intended or actual use of technology for stimulating higher-order thinking. However, our initial literature searches did not yield a body of studies that specifically investigated teachers' attitudes towards the use of technology to foster higher-order thinking. To our knowledge, only one recent study (Bowman et al., 2020) has pursued this goal. Therefore, for the present study we decided to conduct two separate literature reviews, to identify factors that make up (1) teachers' attitudes towards using technology in their teaching and (2) teachers' attitudes towards stimulating higher-order thinking in students.

We see three important reasons for conducting separate reviews. First, teachers may have *differing attitudes* towards technology use and stimulating higher-order thinking. For example, a teacher might have a positive attitude towards technology use, but a negative attitude towards stimulating higher-order thinking, with or without the use of technology. Second, it is possible that *different factors* underlie these teacher attitudes. For example, Zohar et al. (2001) found that most teachers believe that higher-order thinking is more suitable for high-achieving students than for low-achieving students. However, a similar belief has not come up in research on teachers' attitudes towards using technology. Third, because we aimed to explore teachers' attitudes towards *two different behaviours*, it seemed reasonable to assume that different bodies of literature needed to be explored in order get a comprehensive overview.

We thus conducted two literature reviews, where we aimed to answer the following research questions: (R1) What attitudinal factors make up primary school teachers' attitudes towards using technology in their teaching and to what extent do these factors influence teachers' intended or actual use of technology in teaching? (R2) What attitudinal factors make up primary school teachers' attitudes towards stimulating higher-order thinking in their students and to what extent do these factors influence teachers' intended or actual behaviour to stimulate higher-order thinking in their students? This study was conducted in the context of a research project in which we aim to support primary school teachers (teaching 4- to 12-year-old children) in using new technology to stimulate higher-order thinking in learners. Therefore, we focused our reviews primarily on pre- and in-service primary school teachers.

Our review was conducted before the outbreak of the COVID-19 pandemic. Due to the pandemic, many teachers worldwide had to rapidly change from face-to-face teaching to online teaching. Due to this sudden change, many teachers gained additional experience with using technology in their teaching, and this might have impacted their attitudes towards using technology. However, providing online teaching does not necessarily mean that teachers used technology to stimulate higher-order thinking, or that their attitudes towards the use of technology for promoting higher-order thinking practices changed considerably.

Our study aimed to provide a thorough understanding of the factors that make up teachers' attitudes towards technology use in teaching and towards stimulating higher-order thinking. Thus, the identification of these attitudinal factors was the goal of our study. The goal of our study was *not* to provide an overview of pre-pandemic teachers' attitudes, although we share insights about this. The frameworks that result from our literature review might help in the development of measurement instruments to explore teachers' attitudes towards using technology in teaching and towards stimulating higher-order thinking in a post-pandemic period.



In the remainder of this section, we discuss the theoretical underpinnings underlying both reviews. Thereafter, the paper is divided into two parts. Part 1 describes the method and results of our literature review on teachers' attitudes towards using technology in teaching. In Part 2, we describe the method and results of our second literature review, on teachers' attitudes towards stimulating higher-order thinking in students. We end our paper with an overall discussion of the results of both reviews.

## Theoretical underpinnings

### *Theory of Planned Behaviour*

Since definitions of the concept of attitude may vary, especially in the literature on teachers' attitudes towards technology use in education (Scherer et al., 2020), we went back to the core theoretical framework for attitude and its links with behaviour that was developed by Ajzen (1991, 2001): The Theory of Planned Behaviour (TPB).

According to the TPB, human behaviour is guided by three types of subjective perceptions or beliefs: (1) perceptions about the consequences of the behaviour (behavioural beliefs, which can be cognitive and affective), (2) beliefs about the normative expectations of others (normative beliefs), and (3) beliefs about the extent to which a person may or may not be hindered by internal or external factors to enact a behaviour (control beliefs). According to Ajzen (2001), "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). An attitude-object is the entity about which an attitudinal evaluation is made (Ajzen, 1991, 2001) and is usually a specific behaviour.

Based on this conception of attitude, we view attitude as an umbrella term, consisting of three dimensions that together form a person's attitude towards a particular behaviour. These dimensions are comprised of factors that are specific for each behaviour. The first dimension, *perceptions of behavioural attributes,* represents beliefs and feelings a person associates with the specific behaviour, in this case, teachers' (intended) use of technology and stimulation of students' higher-order thinking, respectively. The second dimension, *perceptions of social norms*, represents a person's perception of the social acceptability of the behaviour. The third dimension, *perceptions of behavioural control*, represents the person's perception of the level of control he/she has as far as performing the behaviour. These perceptions can refer to external factors (e.g., availability of resources or time) that impact a persons' perception of control, or internal factors (e.g., perceived capability of performing the behaviour, frequently defined as "self-efficacy", based on Bandura's concept (Ajzen, 2002; Armitage & Conner, 2001).

Although the TPB describes people's beliefs and feelings under one unifying dimension ("perceptions of behavioural attributes"), we decided to evaluate the cognitive (beliefs) and affective (feelings) attributes separately. Thus, we used four dimensions making up attitude. A person's views with regard to each of the factors that comprise these dimensions may impact that person's behavioural intention to perform or not perform that specific behaviour (Ajzen, 1991). It is assumed that the stronger an intention, the more likely it is that the person will enact the behaviour (Ajzen, 1991).

In both reviews, we used the TPB as a framework to analyse and structure the attitudinal factors that we found in the literature, in order to create an overview of important attitudinal factors that make up primary school teachers' attitudes towards (1) using technology in teaching, and (2) stimulating higher-order thinking in learners. We chose to use the TPB because it has proven to be a valuable framework that describes important dimensions that can impact a person's intended and actual behaviour in a number of contexts (for a meta-analytic review on the TPB, see Armitage & Conner, 2001).

### *Teachers' attitudes towards technology use*

In this study, we particularly focused on digital technologies (hardware and software) that teachers can use to support and/or enrich their teaching practices. Some examples of hardware are: smartphones, tablets, computers, 3D printers and educational robots. Software examples are: simulation software, design software, programming software and video-editing software.

Different models have been used to study (attitudinal) factors that impact teachers' technology use (see Table 1). These models vary in the description and number of factors that were explored and results have varied on the influence of such factors on teachers' intended or actual use of technology (for a more in-depth description of the models, see Niederhauser & Lindstrom, 2018).

**Table 1.** Models of factors impacting technology use

| | |
|---|---|
| Technology Acceptance Model (TAM 1) | Davis (1989) |
| TAM 2 | Venkatesh and Davis (2000) |
| TAM 3 | Venkatesh and Bala (2008) |
| Unified Theory of Acceptance and Use of Technology (UTAUT) | Venkatesh et al. (2003) |
| Integrative Model of Behaviour Prediction (IMBP) | Kreijns et al. (2013) |
| Will, Skill, Tool and Pedagogy model (WSTP) | Knezek and Christensen (2016) |
| Technological, Pedagogical, and Content Knowledge framework (TPACK) | Mishra and Koehler (2006) |



We used the four dimensions from the TPB to categorize the attitudinal factors described in these models. The *cognitive dimension* includes beliefs about perceived usefulness (TAM 1, 2, 3; performance expectancy in UTAUT) and perceived ease of use (TAM 1, 2, 3; effort expectancy in UTAUT). The *affective dimension* includes positive (enjoyment) and negative (anxiety) feelings that teachers might experience when using technology in their teaching (TAM 3). The *perceived behavioural control dimension* includes the perceptions teachers have of their own knowledge and skills (self-efficacy) regarding the use of technology in teaching (TAM 3; TPACK; IMBP; WSTP). And the *social norm dimension* includes teachers' perceptions of how people who are important to the teacher (e.g., colleagues, school management) view the use of technology in teaching (TAM 2, 3; UTAUT; IMBP). This categorization served as the starting point for the analysis of the articles that were the results of our broader literature search.

Research on teachers' attitudes towards technology use has been hindered by several theoretical and methodological issues. First, the definition of attitude has varied between studies and has often been poorly articulated. Studies lack a definition or provide an incomplete definition for the construct of attitude (e.g., Konca et al., 2016), fail to explicate the subcomponents of attitude (e.g., Zaranis & Oikonomidis, 2016), or do not distinguish between attitudes and related concepts such as interest (e.g., Meishar-Tal & Ronen, 2016). Second, different terms have been used to refer to the same attitudinal factors. Third, the attitude-object has not always been clearly defined. For example, researchers have sometimes measured teachers' attitudes towards technology use *in general* (e.g., Christensen & Knezek, 2009) rather than their attitudes towards using technology *in teaching*. Due to these theoretical and methodological issues, it is often unclear what attitudinal factors were explored or what the attitude-object was. We aimed to overcome these issues by using the categorization described above to analyse and structure the attitudinal factors that make up primary school teachers' attitudes towards using technology in teaching.

*Teachers' attitudes towards stimulating higher-order thinking*

Definitions of higher-order thinking vary greatly (Lewis & Smith, 1993). Labels such as critical thinking, problem solving, creative thinking, reasoning, metacognition, or reflective thinking are all used to refer to "higher-order thinking". Disciplines also have different perspectives on what higher-order thinking is. For example, philosophers are mostly interested in the use of thinking to decide what to do or believe, whereas psychologists are more interested in how the process of thinking can help people make sense of their experience by constructing meaning and imposing structure (Lewis & Smith, 1993; Ten Dam & Volman, 2004). In our study, we primarily focused on psychology-oriented research, since we are interested in teachers' attitudes towards stimulating the process of higher-order thinking in their students.

The well-known cognitive taxonomy of Benjamin Bloom can be used to develop educational objectives concerning students' thinking on different levels. In a revised version of Bloom's taxonomy, the thinking skills of remembering, understanding, and applying were regarded as lower-order thinking skills and analysing, evaluating, and creating were regarded as higher-order thinking skills (Anderson et al., 2001). King et al. (1998) described higher-order thinking as a set of skills that

> ... include critical, logical, reflective, metacognitive, and creative thinking. These skills are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful application of the skills results in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continued growth in these and other intellectual skills. (p. 1)

Based on the definition of King et al. (1998) and Bloom's revised taxonomy (Anderson et al., 2001), we define *stimulating higher-order thinking* (the attitude object in this study) as follows: offering assignments, questions, problems, or dilemmas where students need to use complex cognitive skills (such as analysing, evaluating, and creating) in order to find a solution or make a decision, prediction, judgement or product.

Despite the commonly held idea that stimulating higher-order thinking skills in students is important, there is little research on teachers' attitudes towards teaching behaviours that promote higher-order thinking, especially when it concerns research on *primary school* teachers' attitudes (Schulz & FitzPatrick, 2016).

Furthermore, we saw similar issues regarding the differences in definitions and the use of different terms to refer to the same underlying attitudinal factors as in the literature on teachers' attitudes towards technology use. Due to differing definitions of higher-order thinking between studies, descriptions of the attitude-object also varied. We aimed to overcome these issues and gain insight into the attitudinal factors that make up primary school teachers' attitudes towards stimulating higher-order thinking by using the TPB to structure our analysis of the literature that addresses this topic.



### PART 1: Teachers' attitudes towards using technology in teaching

## Method

Our literature review followed several consecutive steps. First, we conducted a literature search to collect relevant literature from several scientific databases. Second, we screened titles and abstracts of the collected studies to ensure that they met our inclusion criteria. Then, we analysed the full texts of the remaining documents and did further screening related to relevance and quality; in the final set of 78 included studies, we identified the attitudinal factors that make up primary school teachers' attitudes towards using technology in teaching. Furthermore, we analysed the extent to which these factors impacted teachers' intended or actual technology use, according to the literature reviewed.

### Literature search

The keywords we used for our literature search were synonyms of or substitutes for these words: primary school, teacher, technology, and attitude (see Appendix A). The databases we used were PsycInfo, ERIC, and Scopus. We chose PsycInfo and ERIC because these databases provide a wide selection of social and educational scientific research. Scopus was selected because it provides a wide variety of peer-reviewed scientific studies that might not be found using PsycInfo and ERIC only. We selected documents that were written in English.

Our review was focused on recent (2014-2020) literature, as we expected that this would reflect current developments in technology use in schools. We imported the literature found into the Mendeley reference manager program. We included both quantitative and qualitative studies. Quantitative studies can provide insight into the influence of attitudinal factors on intentions or actual behaviours, which helps us to understand the importance of such factors. Qualitative studies can provide insight into how and why attitudinal factors might impact teachers' use of technology. This could result in the identification of attitudinal factors that were not described in the initial proposed models. After removing duplicates, a set of 1022 documents remained. We excluded dissertations (194), because we expected that the research presented in the dissertations would also be available as research articles, resulting in 826 documents.

## Screening

We first screened the documents based on the title and abstract only. After a discussion in the research team, the following inclusion criteria were formulated for the selection of documents: (1) the research involved pre- or in-service primary school teachers (teaching 4- to 12-year-old children), (2) the research focused on teachers' attitudes towards using technology in teaching. With this step, another 595 documents were excluded. Next, we analysed the full text of the documents. In 44 cases, we had no access to the full text and these studies were then excluded, leaving 187 full-text documents to be analysed.

## Analysis

First, the inclusion criteria (as described above) were again discussed in the research team, to ensure clear interpretation of the criteria. Then, the first author analysed the 187 documents. To ensure transparency, we created an overview table where we described for each study: (1) what labels (i.e., attitudinal factors) were given, (2) example items and/or quotes that substantiated these labels, and (3) if available, a summary of results regarding the relation between the attitudinal factors and behaviour. When there were doubts about the inclusion of a document, the document was discussed in the research team and a decision was made. The overview table is available on request from the authors.

### *Quality checks and inclusion*

To ensure that the included studies were of reasonable quality, we conducted two checks. First, for quantitative studies, the questionnaire items had to be available, or a detailed description of the items provided. Second, for all studies we checked whether the presented conclusions followed logically from the collected data and the analyses. For example, in the case of qualitative studies we evaluated whether the conclusions drawn by the authors were substantiated with data such as quotes. During the analysis of the full texts, another 109 documents were excluded, resulting in a final total of 78 documents (see Table 2). The most important reasons for excluding documents were:

- The authors described their measurement instrument (in quantitative studies) only superficially and did not include the items (e.g., Doğru, 2017).

- Primary school teachers were a minority in the sample used in the study, and the results were not described separately for this group (e.g., Lee et al., 2017).
- The study did not investigate attitudinal factors, but, for example, how *often* teachers used technology in their teaching (e.g., De Koster et al., 2017).

*Identification of attitudinal factors*

Analysis of attitudinal factors was done both deductively and inductively. For our deductive analysis, the first author evaluated whether the reported attitudinal factors were included in our initial categorization (perceived usefulness, perceived ease of use, enjoyment, anxiety, self-efficacy, and subjective norms). If so, the study was labelled accordingly. An article could receive multiple labels if more than one factor was measured. For the inductive analysis, the first author verified for each study whether any additional attitudinal factors were measured and if these factors were reported on in other studies as well. If multiple studies reported data on these factors, they were included in our overview. In this way, we expanded our initial categorization. The results of the deductive and inductive analysis were extensively discussed in the research team.

**Table 2** Types of documents in the body of included studies

| Type of document | Number of studies |
|---|---|
| Scientific journal article | 73 |
| Conference paper | 4 |
| Research report | 1 |
| **Total** | **78** |

# Results

## Critical reflections regarding the reviewed studies

Before presenting the results of this review, several remarks need to be made regarding the theoretical and methodological issues we encountered. First, the studies that were analysed underscored our prior observation that the construct of teachers' attitudes towards using technology is often poorly defined (e.g., Steiner & Mendolevitch, 2017). Instead, most researchers aimed to measure factors that impacted teachers' intended or actual use of technology but did not report them as attitudinal factors (e.g., Kreijns et al., 2014). However, the TPB categorizes these factors (e.g., beliefs, feelings, self-efficacy) as attitudinal.

Owing to the variability in or lack of definitions of attitude, we observed much variability in how the attitudinal factors were measured. For example, in studies that used questionnaires, the instruments varied considerably, resulting in a swamp of items that were used to measure similar underlying attitudinal factors. The use of different sets of items to measure these factors is not necessarily problematic as long as the psychometric quality of the instruments can be determined. However, there was often little or no information on the psychometric quality of the instruments that were used (e.g., Bingimlas, 2017).

Furthermore, multiple underlying attitudinal factors were measured in many studies, but the relation between such factors and teachers' intended or actual use of technology in teaching was not made explicit.

Lastly, there was variation in the types of technology that were explored. For example, our final set of articles included studies focusing on Web 2.0 technologies, ICT, computers, robots, games, and so forth. It is possible that the influence of the underlying attitudinal factors varies depending on the type of technology that is used. Despite these difficulties, we were able to identify nine attitudinal factors, which we will describe according to TPB dimension in the next section.

## Identified attitudinal factors

Table 3 provides an overview of the identified attitudinal factors and how many studies reported on these factors. Factors that were reported on in more than three studies are included in this table. Appendix B provides an overview of the studies that reported on each of the attitudinal factors.

## Cognitive dimension

This dimension represents beliefs that teachers have about using technology in their teaching.

### *Perceived usefulness (PU)*

This type of belief was the most often-reported factor in the reviewed studies (47 studies). The results showed that, in general, most primary school teachers think technology is useful for enriching/improving student learning. Six studies reported on the influence of PU on teachers' intended or actual technology use (Jeong & Kim, 2017; Kreijns et al., 2014; Magen-Nagar & Firstater, 2019; Petko et al., 2018; Pittman & Gaines, 2015; Uluyol & Şahin, 2016). These studies indicated that there was a positive relation between PU and teachers' intended or actual technology use. For example, Jeong and Kim (2017) found that PU had a significant and positive effect on teachers' intention to use technology.

**Table 3.** Number of studies reporting on the identified attitudinal factors

| Factor | Definition | Number of studies | Types of data* | | |
|---|---|---|---|---|---|
| | | | Qualitative | Quantitative | Mixed |
| ***Cognitive dimension*** | | | | | |
| Perceived usefulness | Teachers' beliefs about the usefulness of technology for improving and/or enriching their teaching and the learning of their students | 47 | 18 | 20 | 9 |
| Perceived ease of use | Teachers' beliefs about the ease or difficulty of using technology in their teaching | 9 | 1 | 4 | 4 |
| Perceived relevance | Teachers' beliefs about the importance of using technology in their teaching in order to prepare students for later life | 8 | 5 | 2 | 1 |
| Perceived effect on student motivation | Teachers' beliefs that using technology in teaching motivates students to learn and engages students in learning | 19 | 10 | 7 | 2 |
| ***Affective dimension*** | | | | | |
| Anxiety | Negative feelings such as anxiety or fear when using technology | 6 | 1 | 1 | 4 |
| Enjoyment | Positive feelings such as enjoyment or enthusiasm when using technology | 7 | 2 | 2 | 3 |
| ***Perceived behavioural control dimension*** | | | | | |
| Self-efficacy | Teachers' self-perceived capability to use technology in their teaching | 35 | 9 | 17 | 9 |
| Context dependency | Teachers' perceptions that external factors, (i.e., availability of resources, support, available time) are a prerequisite for them to be able to use technology | 12 | 4 | 5 | 3 |
| ***Social norms dimension*** | | | | | |
| Subjective norms | Teachers' perceptions as to whether other people who are important to that teacher think it is good or bad to use technology in teaching | 19 | 3 | 11 | 5 |

* In some of the mixed-method studies, only the qualitative data were used if the items from the questionnaire were not described.

*Perceived ease of use (PEU)*

Results of the 9 studies regarding PEU indicated that some teachers find it easy to use technology (e.g., Prieto, et al., 2016), but other teachers initially find it difficult to use technology (e.g., Önal et al., 2017). However, these studies reported teachers' PEU related to different types of technology, such as augmented reality, mobile technologies and interactive whiteboards. This might help explain the differences in teachers' perspectives regarding ease of use.

The influence of PEU on teachers' intended or actual use of technology is unclear. Only Jeong and Kim (2017) studied the relationship between PEU and intention explicitly. They found that PEU did not have a direct significant impact on teachers' intention to use technology. However, PEU did have a direct significant impact on PU, which had a significant positive impact on teachers' intention to use technology. Similarly, Šumak et al. (2017) found that PEU had a significant positive impact on PU. The strength of this impact differed between prospective and practicing teachers. However, Šumak et al. did not estimate to what extent PU influenced the intention to use technology, but assumed that PU (and therefore PEU, indirectly) impact intention, based on research by Venkatesh et al., 2003.

*Perceived relevance (PR)*

Results of the 8 studies on PR indicated that primary school teachers think it is important to use technology in their teaching to prepare students for later life. However, the relation between PR and intended or actual use of technology was not studied explicitly in any of these studies. Instead, the researchers seemed to assume that beliefs about the relevance of using technology are a reason for teachers to use technology.

*Perceived effect on student motivation (PESM)*

Results of the 19 studies on PESM indicated that most primary school teachers believe that using technology motivates and engages their students. In two qualitative studies, participants responded that they felt technology motivates students to learn or engages students in learning, and that they therefore use technology in their teaching (Carver, 2016; Uluyol & Şahin, 2016).

## Affective dimension

This dimension represents feelings that teachers have about using technology in their teaching.

*Anxiety (AX)*

Results of the 6 studies on anxiety indicated that some teachers experienced anxiety when using technology. For example, Ünal et al. (2017) found that a minority of teachers reported negative emotions when using technology. In two studies (Coleman et al., 2016; Rehmat & Bailey, 2014), the relationship between AX and teachers' intended or actual use of technology was explored. These results were mixed. Rehmat and Bailey (2014) found that due to their high anxiety, several teachers were reluctant to incorporate technology. In contrast, Coleman et al. (2016) found no significant effect of AX on teachers' preparedness to plan lessons that involve using computers.



*Enjoyment (EY)*

Results of the 7 studies addressing enjoyment indicated that teachers can experience positive feelings when using technology in teaching. However, only two studies reported on the influence of EY on teachers' (intended) use of technology. Kreijns et al. (2014) stated that attitude is formed by affective (enjoyment) and instrumental (beliefs about the usefulness of technology) dimensions and used bipolar items to measure these dimensions. They found that a considerable part of the variance in intention to use technology could be explained by attitude, suggesting that both PU and EY impacted intention. Furthermore, Ünal et al. (2017) found that the majority of pre-service primary teachers in their sample (9 out of 15) experienced positive emotions while using technology in their teaching, which encouraged these teachers to make use of technology.

## Perceived behavioural control dimension

This dimension represents perceptions of control that teachers have related to using technology in their teaching.

*Self-efficacy (SE)*

In several of the reviewed studies, the TPACK model was used as a framework to determine teachers' perceived knowledge and skills regarding technology use. Depending on the measures used, these studies were labelled as addressing "self-efficacy". For example, items such as "I am able to use technology to create real-world scenarios for my students" (Liu et al., 2015, p. 71) may originally have been used to measure teachers' technological pedagogical knowledge, but also fit the definition of self-efficacy.

In 12 studies, the relation between SE and intended or actual use of technology was explored. Their results fell into two categories: (1) the extent to which SE impacted teachers' intended or actual use of technology, and (2) the extent to which a *lack* of SE formed a barrier for teachers' use of technology in their teaching. Eight studies belonged in the first category (Alhassan, 2017; Jeong & Kim, 2017; Jung et al., 2019; Kreijns et al., 2014; Petko et al., 2018; Trainin et al., 2018; Uslu & Usluel, 2019; Vanderlinde et al., 2014). The results of these studies showed that, in general, increased SE had a positive impact on teachers' intended or actual use of technology.

Four studies belonged in the second category (Awang et al., 2018; Bingimlas, 2017; Khanlari, 2016; Shadreck, 2015). The results of these studies showed that a lack of knowledge and skills was perceived by teachers as a barrier to their use of technology. Teachers rated the impact of that barrier from being somewhat limiting to being a major limitation.

### *Context dependency (CD)*

In 12 studies the impact of CD on teachers' intended or actual use of technology was described. The prerequisite conditions that were perceived as barriers, according to these studies, were: lack of access to good quality technological materials (Awang et al., 2018; Bingimlas, 2017; González-Carriedo & Esprivalo Harrel, 2018; Jones, 2017; Khanlari, 2016; O'Neal et al., 2017; Tonui et al., 2016), time (Bingimlas, 2017; Frazier et al., 2019; González-Carriedo & Esprivalo Harrel, 2018; Jones, 2017; Khanlari, 2016; O'Neal et al., 2017; So et al., 2014, Vatanartiran & Karadeniz, 2015), unavailability of ready-made assignments that describe how teachers should use technology in their teaching (Norris et al., 2015; Vatanartiran & Karadeniz, 2015), insufficient training on how to implement technology (Frazier et al., 2019; Khanlari, 2016; Tonui et al., 2016; Uluyol & Şahin, 2016), and lack of technical support (Khanlari, 2016; O'Neal et al., 2017).

## Social norm dimension

This dimension represents teachers' perceptions of the social acceptability of using technology in their teaching.

### *Subjective norms (SN)*

In 15 studies, teachers noted that they regarded their colleagues or school administrators as important people whose opinion they valued (Bingimlas, 2017; Cheng & Weng, 2017; Frazier & Trekles, 2018, Frazier et al., 2019; Jeong & Kim, 2017; Jung et al., 2019; Peng & Wong, 2018; Roussinos & Jimoyiannis, 2019; Shin, 2015; Sipilä, 2014; Stieler-Hunt & Jones, 2017; Uluyol & Şahin, 2016; Uslu & Usluel, 2019; Wu et al., 2019; Zehra & Bilwani, 2016). In other studies, the important other was not made explicit, but referred to as: "important people" (Prieto et al., 2016) or a list of potentially important "others" was given (Kreijns et al., 2014). Ünal et al. (2017) involved pre-service elementary teachers in their study, and here the important other was their instructor. Two studies explicitly mentioned teachers' perceptions of what parents think about technology use (Peng & Wong, 2018; Vatanartiran & Karadeniz, 2015).

Five studies (Bingimlas, 2017; Jeong & Kim, 2017; Jung et al., 2019; Kreijns et al., 2014; Shin, 2015) reported on the influence of SN on intended or actual use of technology in teaching. For example, Kreijns et al. (2014) found that SN had little influence on teachers' intention to use technology. In contrast, Jeong and Kim (2017) and Jung et al. (2019) found that SN exerted a significant and positive effect on teachers' (intended) technology use. Shin (2015) found that some teachers (154 of 659) thought administrators' perceptions regarding technology use was the most important factor influencing technology integration.



## Conclusions

Figure 1 presents the identified attitudinal factors and the number of studies exploring the influence of these factors on teachers' (intended) use of technology in teaching. The influence of self-efficacy (SE) and of context dependency (CD) on teachers' (intended) use of technology were most often reported, and the results regarding SE and CD were similar over multiple studies. From this, we conclude that it is likely that SE and CD influence teachers' intended or actual use of technology. Given that six studies reported a positive influence of perceived usefulness (PU) on teachers' (intended) use of technology in teaching, we conclude that PU is another factor to consider when we wish to motivate teachers to use technology in their teaching. Based on the results regarding subjective norms (SN), we conclude that the influence of SN can vary between teachers, where some teachers might be influenced by SN and other teachers might not.

Surprisingly, the influence of each of the factors perceived ease of use, perceived effect on student motivation, perceived relevance, anxiety, and enjoyment on teachers' (intended) use of technology was studied in two or fewer studies. Therefore, we cannot draw conclusions about the influence of these factors on (intended) use of technology. This emphasizes the importance of studying the influence of attitudinal factors on teachers' (intended) use of technology. Without insight into the influence of the attitudinal factors, we do not know which of the identified factors are important to consider if we wish to motivate teachers to use technology in their teaching.

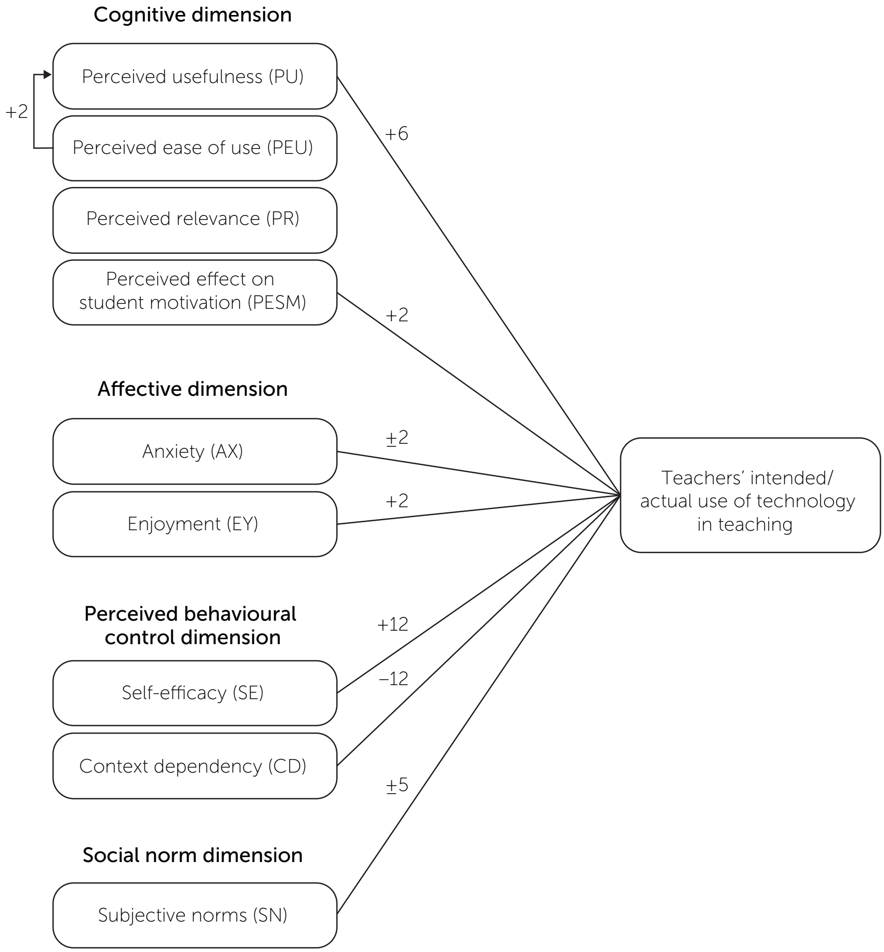


**Figure 1:** Studies investigating the influence of the attitudinal factors on teachers' (intended) use of technology in teaching

Notes:

1. Numbers refer to the number of studies investigating the influence on teachers' intended/actual technology use.
2. Positive (+), negative (-), or varied (±) influence on teachers' intended/actual technology use.

PART 2: Teachers’ attitudes towards stimulating higher-order thinking

## Method

For this review, we used the same steps as for our review in Part 1 on teachers’ attitudes towards using technology in teaching.



### Literature search

The databases that we used were PsycInfo, ERIC, and Scopus. We selected documents that were written in English. The keywords were synonyms of or substitutes for the words: primary school, teacher, higher-order thinking and attitude.

Because we anticipated varying definitions for higher-order thinking, we evaluated different sets of keywords when setting up our search string. We started with a broad set of keywords that included terms such as: “higher order skill*”, “creativity”, “convergent thinking” and “divergent thinking”. In addition, we explored the ERIC thesaurus, to identify keywords related to higher-order thinking that might be included in our search. For each of these keywords, we evaluated whether it helped in finding additional relevant literature. Based on these evaluations a final set of keywords was used, which is presented in Appendix C.

Similar to our review on teachers’ attitudes towards using technology in teaching, we included both quantitative and qualitative studies, for the same reasons. While conducting this literature search, it became clear that there was not much research on teachers’ attitudes towards stimulating higher-order thinking. We therefore decided to include all of the literature that surfaced from our search and then decide on a reasonable selection period. This resulted in a set of 1001 documents. We imported this set of documents into the Mendeley reference manager program. Duplicates were removed (58), resulting in 943 documents.

A citation report from Web of Science showed increased attention to the topic “higher order thinking” from 2000 onwards. Therefore, we chose 2000 as a cut-off point for selecting literature, resulting in a set of 690 documents. We again excluded dissertations (68), resulting in 622 documents.

### Screening

We first screened the documents based on the title and abstract only. After a discussion in the research team, the following inclusion criteria were formulated for the selection of documents: (1) the research involved pre- or in-service primary school teachers (teaching 4- to 12-year-old children), (2) the research focused on teachers’ beliefs or attitudes towards stimulating one or more higher-order thinking skills. With this step, 540 documents were excluded. Then, we analysed the full text of the documents. In 14 cases the full text was not available, leaving 68 documents for full-text analysis.

## Analysis

First, the inclusion criteria (as described above) were again discussed in the research team, to ensure clear interpretation of the criteria. Then the first author analysed the 68 documents. To ensure transparency we created an overview table where we described for each study: (1) what labels (i.e., attitudinal factors) were given, (2) example items and/or quotes that substantiated these labels, and (3) if available, a summary of results regarding the relation between the attitudinal factors and behaviour. The overview table is available on request from the authors. When there were doubts about the inclusion of a document, the document was discussed in the research team and a decision was made.

### *Quality checks and inclusion*

In order to ensure that the studies included in our analysis were of reasonable quality, we conducted the same two checks we used in our previous review (see "Quality checks and inclusion" on page 10). During the analysis of the full texts another 50 documents were excluded, resulting in a set of 18 documents (see Table 4). The main reasons for excluding documents were:

- The authors described their measurement instrument (in quantitative studies) only superficially and did not include the items (e.g., Mahiroglu, 2007).
- The paper did not investigate attitudinal factors related to stimulating higher-order thinking in students. The study focused, for example, on student attitudes (e.g., Liu, 2003) or measured (pre-service) teachers' ability to engage in higher-order thinking themselves (e.g., Sali & Akyol, 2015).

**Table 4** Types of documents in the body of included studies

| Type of document | Number of studies |
|---|---|
| Scientific journal article | 16 |
| Research report | 1 |
| Conference paper | 1 |
| **Total** | **18** |

### *Identification of attitudinal factors*

Because we had no initial categorization available for this review, analysis of the documents was done inductively. The first author labelled the studies based on the reported attitudinal factors. For each study, it was verified which attitudinal factors were measured and if these factors were reported on in other studies as well. If multiple studies reported on these factors, the factors were included in our overview. A study could receive multiple labels if more than one attitudinal factor was described. Again, the results of the analysis were discussed in the research team until consensus was reached.



# Results

## Critical reflections regarding the reviewed studies

As described in the introduction, we expected that less research had been done on teachers' attitudes towards stimulating higher-order thinking in students. The results from this review confirmed that expectation. As is clear from table 4, there are not many studies that address attitudinal factors related to teachers' intention or behaviour to stimulate higher-order thinking in students. This is especially remarkable in light of the increased attention in educational literature and practice on 21st-century learning, which includes higher-order thinking skills (Voogt & Pareja Roblin, 2012). Possibly related to this lack of previous work, we noticed that most of the studies had an exploratory character, where the goal of the study was to gain insight into how teachers evaluate teaching one or more higher-order thinking skills.

Furthermore, the results underscore our statement in the introduction that there is much variability in how higher-order thinking is defined. As a result, the literature described in table 4 varied in the attitude-objects studied. Studies focused on teaching thinking (e.g., Akinoglu & Karsantik, 2016; Baysal et al., 2011), stimulating problem solving (e.g., Lee et al., 2000), or higher-order thinking (e.g., Kamarulzaman & Kamarulzaman, 2016; Schulz & FitzPatrick, 2016) which, although related, are conceptually different skills. Due to this variability, it is possible that the impact of the attitudinal factors on the overall attitude of teachers varies.

Another remarkable observation was that, although several attitudinal factors were measured in the reviewed studies, the relationship between such factors and teachers' intended or actual teaching behaviour was not made explicit in any of the studies. Therefore, it is not possible to draw conclusions about the influence of these attitudinal factors on teachers' intended or actual behaviour aimed at stimulating higher-order thinking. However, the reviewed studies provided information on why teachers do or do not stimulate higher-order thinking, which allowed us to identify several attitudinal factors (see Appendix D for an overview of these studies).

## Identified attitudinal factors

Table 5 provides an overview of the identified attitudinal factors and how many studies reported on these factors. Appendix D provides an overview of the attitudinal factors with reference to the studies that reported on each of them.

## Cognitive dimension

This dimension represents beliefs that teachers have about stimulating higher-order thinking in students.

### *Perceived relevance (PR)*

Results of the 9 studies on PR indicated that most primary school teachers think it is important to stimulate higher-order thinking in students. Tornero (2017) found that even though not all teachers made statements about the importance of stimulating higher-order thinking if they were not explicitly asked about this, a majority of teachers tended to criticize current teaching practices, saying that "students don't think, and they only learn to follow instructions…" (p. 140). This criticism indicates, according to Tornero, teachers' frustration about a lack of focus on higher-order thinking in current teaching practices. This frustration suggests that teachers think it is important to stimulate higher-order thinking.

### *Perceived student ability (PSA)*

Seven out of the nine studies on PSA (Alwadai, 2014; Cheeseman, 2018; Csíkos & Szitányi, 2020; Ketelhut et al., 2020; Lee et al., 2000; Rich et al., 2019; Schulz & FitzPatrick, 2016) found that teachers doubted students' capability to engage in higher-order thinking. For example, Schulz and FitzPatrick (2016) found that teachers were uncertain whether all students can learn to think on a higher level. They believed that all students should be exposed to higher-order thinking, but not all students would be successful in this. Kamarulzaman and Kamarulzaman (2016) found that teachers thought that most students, depending on their level of intelligence, are capable of engaging in higher-order thinking.

## Perceived behavioural control dimension

This dimension represents perceptions of control that teachers associate with stimulating higher-order thinking in students.

### *Self-efficacy (SE)*

Results of the 7 studies regarding SE were somewhat mixed. For example, Tornero (2017) found that five out of 11 pre-service teachers felt fairly confident about their ability to promote reasoning in students. However, three out of 11 teachers reported that they felt insufficiently prepared to be able to do this. Schulz and FitzPatrick (2016) and Cheeseman (2018) found that teachers were uncertain about how to teach and assess thinking. On the other hand, Akinoglu and Karsantik (2016), Baysal et al. (2010), and Lee et al. (2000) found that the majority of teachers felt moderately capable of stimulating higher-order thinking skills.

**Table 5** Number of studies reporting on the identified attitudinal factors

| Factor | Definition | Number of studies | Types of data | | |
|---|---|---|---|---|---|
| | | | Qualitative | Quantitative | Mixed |
| ***Cognitive dimension*** | | | | | |
| Perceived relevance | Teachers' belief about the importance of stimulating higher-order thinking in students in order to help them develop the necessary skills they will need in later life | 9 | 7 | 0 | 2 |
| Perceived student ability | Teachers' beliefs about the capacity of students to engage in higher-order thinking | 9 | 7 | 1 | 1 |
| ***Affective dimension*** | | - | - | - | - |
| ***Perceived control dimension*** | | | | | |
| Self-efficacy | Teachers' self-perceived capability to stimulate higher-order thinking in students | 7 | 3 | 4 | 0 |
| Context dependency | Teachers' perception that external factors are a prerequisite for being able to stimulate higher-order thinking in students | 10 | 6 | 2 | 2 |
| ***Social norm dimension*** | | - | - | - | - |

*Context dependency (CD)*
In 10 studies, teachers reported external factors *might* hinder them in stimulating higher-order thinking in students. In all but three studies (Akinoglu & Karsantik, 2016; Ketelhut et al., 2020; Kurtdede-Fidan & Aydoğdu, 2018) lack of time was reported as an obstructing factor. Limited access to materials (Cheeseman, 2018; Hamdan & Saud Al-Salouli, 2013; Kurtdede-Fidan & Aydoğdu, 2018; Lee et al., 2000), insufficient teacher training (Akinoglu & Karsantik, 2016; AlJaafil & Şahin, 2019; Al-Nouh et al., 2014), crowded classes (AlJaafil & Şahin, 2019; Kurtdede-Fidan & Aydoğdu, 2018) and an overloaded curriculum (AlJaafil & Şahin, 2019; Ketelhut et al., 2020; Kurtdede-Fidan & Aydoğdu, 2018) were also mentioned.

## Conclusions

Figure 2 presents the four identified attitudinal factors. Although we had expected that there would be less research on teachers' attitudes towards stimulating higher-order thinking in students compared to teachers' attitudes towards using technology in teaching, we had not expected that there would be so little research on this topic, especially since the importance of developing higher-order thinking skills is emphasized in many documents regarding 21st-century learning (Voogt & Pareja Roblin, 2012; World Economic Forum, 2016) and stimulation of higher-order thinking is considered by many teachers as a fundamental aspect of teaching.

Perceived relevance (PR) and perceived student ability (PSA) pertain to the cognitive dimension and self-efficacy (SE) and context dependency (CD) pertain to the perceived behavioural control dimension. However, in the reviewed studies we found no mention of attitudinal factors that fit the affective and social norms dimensions of the TPB. This does not mean that factors such as enjoyment, anxiety or subjective norms are unimportant, but simply that the reviewed studies did not include these factors. Furthermore, there were no results regarding the influence of the identified factors on teachers' intended or actual behaviour aimed at stimulating higher-order thinking in students. These results emphasize the need to study primary school teachers' attitudes towards stimulating higher-order thinking in students so we may learn what teachers need to engage in teaching practices that help students develop higher-order thinking skills.

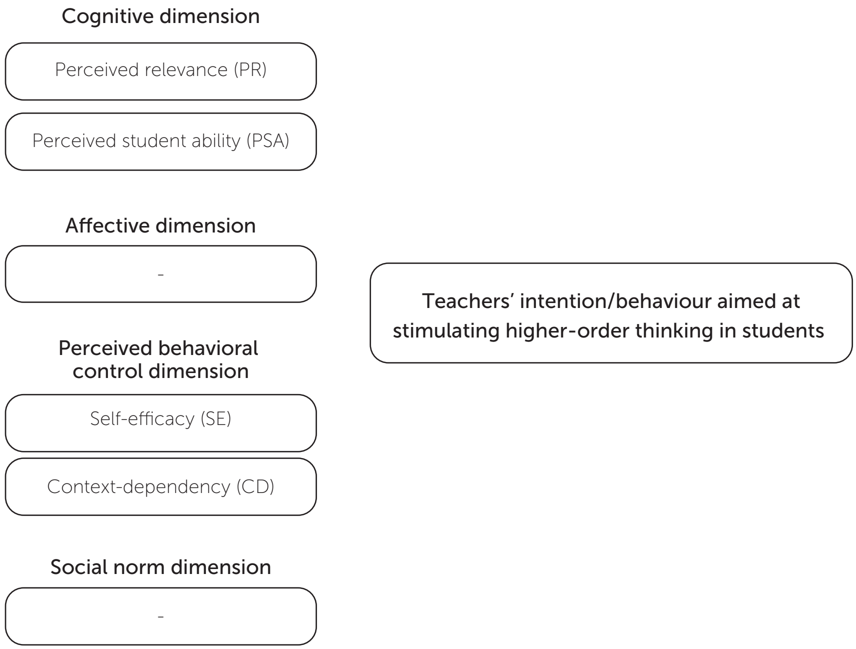


**Figure 2:** Studies exploring the influence of the attitudinal factors on teachers' intention/behaviour aimed at stimulating higher-order thinking in students

Notes:
1. No studies reported on the influence of the identified factors on teachers' intention/behaviour aimed at stimulating higher-order thinking in students.

# Overall discussion

In the present study, we conducted two separate literature reviews to identify factors that make up primary school teachers' attitudes towards using technology *and* towards stimulating higher-order thinking. As indicated in our introduction, we used the attitudinal structure that is outlined in the Theory of Planned Behaviour (Ajzen, 1991, 2001) to capture the construct of teachers' attitudes in these two contexts. We believe it is important to carry out these reviews, because insight into these two types of attitudes and related behaviours is a first step towards understanding primary school teachers' intended and actual use of technology for stimulating higher-order thinking in students.

## Outcomes of both reviews

We were able to identify nine attitudinal factors related to primary school teachers' attitudes towards using technology in their teaching and four factors related to primary school teachers' attitudes towards stimulating higher-order thinking (see Tables 3 and 5). Our review showed a messy picture of research on teachers' attitudes towards using technology. This messiness might be caused by the varying operationalizations of the construct of attitude.

Our findings are corroborated by Scherer et al. (2020). While they used a meta-analytic approach to examine the factor structure of the 'technology acceptance' construct, we took a theoretical approach to studying teachers' attitudes towards technology. Scherer et al. (2020) observed a variety of indicators and measurement instruments with which technology acceptance is measured (such as perceived usefulness, perceived ease of use, self-efficacy, attitude, subjective norms and facilitating conditions) and found that these indicators form one latent construct: "technology acceptance". While we agree with Scherer et al. (2020) that a comprehensive way of measuring teachers' attitudes towards technology is lacking, we argue that this is because most studies started from an incomplete theoretical basis in studying teachers' attitudes towards technology use. We therefore advise researchers who study teachers' attitudes towards technology integration to start from a sound theoretical framework, such as the TPB. Our review showed a similar picture for studies about teachers' attitudes towards stimulating higher order thinking. These studies also often lacked a clear theoretical basis.

Furthermore, we argue that although several attitudinal factors related to technology use were explored in multiple studies (see Table 3), the impact of these factors on intended or actual technology use was hardly studied. In addition, Scherer et al. (2020) found insufficient evidence for the assumption that teachers' intention to use technology has a significant influence on teachers' actual use of technology. Similarly, none of the reviewed studies on stimulating higher-order thinking explored the influence of the attitudinal factors on (intended) teaching behaviour. We see a need for studies that explore the influence of the attitudinal factors on teachers' technology use and teaching behaviour aimed at stimulating higher-order thinking, based on clear theoretical frameworks such as the TPB. In this way, we can learn what attitudinal factors are important to consider if we wish to support teachers in using technology for stimulating higher-order thinking in students.

The four identified factors that made up primary school teachers' attitudes towards stimulating higher-order thinking pertain to only two dimensions (the cognitive and perceived behavioural control dimensions) of the TPB. This might be caused by the limited number of studies (18) in which this attitude was studied. We therefore urge researchers to explore whether additional attitudinal factors pertaining to the affective and subjective norms dimension are also important.

## Limitations

The most important limitation of our review on teachers' attitudes towards using technology was the variability between studies. Similar to Scherer et al. (2020), we observed considerable variation between studies regarding the descriptions of the attitudinal factors, the way these factors were measured and information regarding the psychometric quality of the used instruments. Due to this variability, it was sometimes difficult to compare the results of different studies. We observed similar variation between studies on teachers' attitudes towards stimulating higher-order thinking in students.

In an attempt to overcome these difficulties, we introduced the two "quality checks". Quantitative studies were only included if the questionnaire items that were used were available, or a detailed description of the items was provided. However, we realize that this is not a very strong indicator of study quality. Our initial aim was to only include studies that used validated questionnaires. However, this proved to be more difficult than initially anticipated, due to the diverse methods by which authors validated their instruments. In some studies, factor analyses were used, while in others only reliability coefficients were reported. Other studies used an adapted version of a previously validated instrument but did not re-evaluate its reliability and validity. Sometimes it was unclear if and in what way instruments were validated. We therefore decided to use the quality check, as described above.

Furthermore, although our second quality check, whether the presented conclusions followed logically from the collected data and analyses, might be interpreted as somewhat 'fuzzy', we used it as an extra check on the quality of the study. We used this one mainly to evaluate the qualitative studies, which were only included for analysis if the conclusions drawn by the authors were substantiated with data such as quotes.

## Future research

The two reviews resulted in two frameworks that provide a structure for the development of valid and reliable measures of each attitudinal factor. We intend to develop and validate such measures in our next study. Such measures can be used to gain insight into these teacher attitudes. Furthermore, these measures can be combined to investigate different typologies of teachers. For example, by combining measures for both attitudes we may find that many teachers believe that it is relevant to use technology and to stimulate higher-order thinking. Some of these teachers may feel capable of using technology in their teaching but feel insufficiently capable of stimulating higher-order thinking, whereas others might not feel capable of using technology but are confident about their capability to stimulate higher-order thinking. Such typologies could provide insight into the needs of different groups of teachers, which would allow us to develop professional development that can support teachers in their use of technology for stimulating higher-order thinking. Furthermore, measures of the separate attitudinal factors can be combined with measures of teachers' frequency of technology use and their behaviour aimed at stimulating higher-order thinking. This would allow us to study the relationship of the identified attitudinal factors with teachers' technology use and teaching behaviour.

As described in the introduction, this study was conducted before the outbreak of the COVID-19 pandemic. The pandemic has had a major impact on teachers' use of technology, since many teachers have had to teach online. This may mean that many teachers have become more skilled in the use of technology for online teaching. However, even if teachers have become more technologically skilled, we do not yet know whether and how their attitudes towards technology use have changed. In addition, we do not yet know whether and how this might affect teachers' attitudes towards higher-order thinking and the use of technology for stimulating higher-order thinking. By identifying factors that make up primary school teachers' attitudes towards technology use and towards higher-order thinking, our study may provide a solid basis to further study the effects of the pandemic in this regard.

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*+ Included in review 2: teachers' attitudes towards stimulating higher-order thinking in students*


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# Appendix A: Keywords used in literature search for review on teachers' attitudes towards using technology in teaching

**Table A1** Keywords used in search on teachers' attitudes towards using technology in teaching

| Search term | Used keywords |
|---|---|
| Primary school | "elementary education" OR "elementary school*" OR "primary education" OR "primary school*" OR "K-6*" OR "K6" OR "1st-grade*" OR "first-grade*" OR "grade 1" OR "grade one" OR "2nd-grade*" OR "second-grade*" OR "grade 2" OR "grade two" OR "3rd-grade*" OR "third-grade*" OR "grade 3" OR "grade three" OR "4th-grade*" OR "fourth-grade*" OR "grade 4" OR "grade four" OR "5th-grade*" OR "fifth-grade*" OR "grade 5" OR "grade five" OR "6th-grade*" OR "sixth-grade*" OR "grade 6" OR "grade six" |
| Teacher | "teacher*" OR "educator*" or "tutor*" OR "instructor*" |
| Technology use | "technolog*" OR "new media" OR "ICT*" OR "information and communication technolog*" OR "educational technolog*" OR "integrated learning system" OR "digital learning material*" OR "information technolog*" |
| Attitude | "attitude*" OR "belief*" OR "preference" OR "self-efficacy" |

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# Appendix B: Overview of the literature on teachers' attitudes towards using technology in teaching

**Table B1** Overview of reviewed studies (*N* = 78), organized by attitudinal factor

| Attitudinal factor | Studies |
|---|---|
| Perceived usefulness (*n* = 47) | Awang et al. (2018); Baek et al. (2017); Camilleri (2018); Carver (2016); De Aldama & Pozo (2016); Del Pozo et al. (2017); Domingo & Garganté (2016); Frazier & Trekles (2018); González-Carriedo & Esprivalo Harrel (2018); Gudmundsdottir & Hatlevik (2018); Han et al. (2019); Heitink et al. (2016); Jeong & Kim (2017); Jones (2017); Kao et al. (2020); Kartal & Çinar (2018); Kayalar (2016); Khanlari (2016); Kreijns et al. (2014); Leem & Sung (2019); Lehtinen et al. (2016); Magen-Nagar & Firstater (2019); Marbán & Mulenga (2019); Meishar-Tal & Ronen (2016); Mertala (2017); Neofotisto & Karavakou (2018); Ningsih & Mulyono (2019); Önal et al. (2017); Peng & Wong (2018); Petko et al. (2018); Pinder (2018); Pittmann & Gaines (2015); Prieto et al. (2016); Rana et al. (2018); Saudelli & Ciampa (2016); Steiner & Mendolevitch (2017); Stieler-Hunt & Jones (2015, 2017); Šumak et al. (2017); Tsai (2019); Uluyol & Şahin (2016); Walsh & Farren (2018); Wu et al. (2019); Zaranis & Oikonomidis, (2016); Zehra & Bilwani (2016); Zhang (2019); Županec et al. (2014) |
| Perceived ease of use (*n* = 9) | Alhassan (2017); Jeong & Kim (2017); Kao et al. (2020); Leem & Sung (2019); Ningsih & Mulyono (2019); Önal et al. (2017); Pinder (2018); Prieto et al. (2016); Šumak et al. (2017) |
| Perceived relevance (*n* = 8) | González-Carriedo & Esprivalo Harrel (2018); Jones (2017); Magen-Nagar & Firstater (2019); Meishar-Tal & Ronen (2016); Mertala (2017); O'Neal et al. (2017); Pittman & Gaines (2015); Zehra & Bilwani (2016) |
| Perceived effect on student motivation (*n* = 19) | Anđić et al. (2018); Carver (2016); De Aldama & Pozo (2016); Domingo & Garganté (2016); Dostál et al. (2017); Dunn & Sweeney (2018); González-Carriedo & Esprivalo Harrel (2018); Han et al. (2019); Konca et al. (2016); Marbán & Mulenga, 2019; Mertala (2017); O'Neal et al. (2017); Song, 2018; Stieler-Hunt & Jones (2015); Tsai (2019); Uluyol & Şahin (2016); Zehra & Bilwani (2016); Zhang (2019); Županec et al. (2014) |
| Anxiety (*n* = 6) | Coleman et al. (2016); Frazier & Trekles (2018); González-Carriedo & Esprivalo Harrel (2018); Öztürk (2018); Rehmat & Bailey (2014); Ünal et al. (2017) |

Table B1 Continued

| Attitudinal factor | Studies |
|---|---|
| Enjoyment (*n* = 7) | González-Carriedo & Esprivalo Harrel (2018); Kreijns et al. (2014); Rehmat & Bailey (2014); Stieler-Hunt & Jones (2017); Tonui et al. (2016); Tsai (2019); Ünal et al. (2017) |
| Self-efficacy (*n* = 35) | Alhassan (2017); Awang et al. (2018); Bingimlas (2017); Camilleri (2018); Frazier & Trekles (2018); Frazier et al. (2019); Gudmundsdottir & Hatlevik (2018); Heitink et al. (2016); Jeong & Kim (2017); Jones (2017); Jung et al. (2019); Khanlari (2016); Kartal & Çinar (2018); Kazu & Erten (2014); Kreijns et al. (2014); Lehtinen et al. (2016); Liu et al. (2015); Magen-Nagar & Firstater (2019); Petko et al. (2018); Rehmat & Bailey (2014); Roussinos & Jimoyiannis (2019); Saudelli & Ciampa (2016); Shadreck (2015); Sipilä (2014); Song (2018); Tai (2015); Trainin et al. (2018); Tsai (2019); Uslu & Usluel (2019); VanderLinde et al. (2014); Vatanartiran & Karadeniz, (2015); Walsh & Farren (2018); Zhang (2019); Zipke et al. (2019); Županec et al. (2014) |
| Context dependency (*n* = 12) | Awang et al. (2018); Bingimlas (2017); Frazier et al. (2019); González-Carriedo & Esprivalo Harrel (2018); Jones (2017); Khanlari (2016); Norris et al. (2015); O'Neal et al. (2017); So et al. (2014); Tonui et al. (2016); Uluyol & Şahin (2016); Vatanartiran & Karadeniz (2015) |
| Subjective norms (*n* = 19) | Bingimlas (2017); Cheng & Weng (2017); Frazier & Trekles (2018); Frazier et al. (2019); Jeong & Kim (2017); Jung et al. (2019); Kreijns et al. (2014); Peng & Wong (2018); Prieto et al. (2016); Roussinos & Jimoyiannis (2019); Shin (2015); Sipilä (2014); Stieler-Hunt & Jones (2017); Uluyol & Şahin (2016); Ünal et al. (2017); Uslu & Usluel (2019); Vatanartiran & Karadeniz (2015); Wu et al. (2019); Zehra & Bilwani (2016) |

# Appendix C: Keywords used for literature search for review on teachers' attitudes towards stimulating higher-order thinking

**Table C1** Keywords used in search on teachers' attitudes towards stimulating higher-order thinking

| Search term | Used keywords |
|---|---|
| Primary school | "elementary education" OR "elementary school*" OR "primary education" OR "primary school*" OR "K-6*" OR "K6" OR "1st-grade*" OR "first-grade*" OR "grade 1" OR "grade one" OR "2nd-grade*" OR "second-grade*" OR "grade 2" OR "grade two" OR "3rd-grade*" OR "third-grade*" OR "grade 3" OR "grade three" OR "4th-grade*" OR "fourth-grade*" OR "grade 4" OR "grade four" OR "5th-grade*" OR "fifth-grade*" OR "grade 5" OR "grade five" OR "6th-grade*" OR "sixth-grade*" OR "grade 6" OR "grade six" |
| Teaching | "teacher*" OR "educator*" or "tutor*" OR "instructor*" |
| Higher-order thinking | "thinking skills" OR "abstract reasoning" OR "creative thinking" OR "critical thinking" OR "decision making skills" OR "logical thinking" OR "metacognition" OR "problem solving" |
| Attitude | "attitude*" OR "belief*" OR "preference" OR "self-efficacy" |

# Appendix D: Overview of the literature on teachers' attitudes towards stimulating higher-order thinking in learners

**Table D1** Overview of reviewed studies (*N* = 18), organized by attitudinal factor

| Component | Studies |
|---|---|
| Perceived relevance (*n* = 9) | AlJaafil & Şahin (2019); Al-Nouh et al. (2014); Alwadai (2014); Chan & Yuen (2013); Ketelhut et al. (2020); Kurtdede-Fidan & Aydoğdu (2018); Liu et al. (2012); Schulz & FitzPatrick (2016); Tornero (2017) |
| Perceived student ability (*n* = 9) | AlJaafil & Şahin (2019); Alwadai (2014); Cheeseman (2018); Csíkos & Szitányi (2020); Kamarulzaman & Kamarulzaman (2016); Ketelhut et al. (2020); Lee et al. (2000); Rich et al. (2019); Schulz & FitzPatrick (2016) |
| Self-efficacy (*n* = 7) | Akinoglu & Karsantik (2016); Baysal et al. (2010); Cheeseman (2018); Koç (2020); Lee et al. (2000); Schulz & FitzPatrick (2016); Tornero (2017) |
| Context dependency (*n* = 10) | Akinoglu & Karsantik (2016); AlJaafil & Şahin (2019); Al-Nouh et al. (2014); Alwadai (2014); Chan & Yuen (2013); Cheeseman (2018); Hamdan & Saud Al-Salouli (2013); Ketelhut et al. (2020); Kurtdede-Fidan & Aydoğdu (2018); Lee et al. (2000) |

# 3

# Measuring primary school teachers' attitudes towards new technology use: Development and validation of the TANT questionnaire

This chapter is based on: Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2022). *Measuring primary school teachers' attitudes towards new technology use: Development and validation of the TANT questionnaire.* [Manuscript submitted for publication]. Department for teacher development, University of Twente.

## Abstract

This study concerns the development and validation of a questionnaire to measure primary school Teachers' Attitudes towards New Technology use in teaching (TANT). Many researchers, policy makers and educators have emphasized the importance of using *new* technology in teaching. However, no instrument is available to measure teachers' attitudes towards using *new* technology in teaching. In a previous literature study (Wijnen et al., 2021), we used the well-known Theory of Planned Behaviour to identify and structure eight underlying factors that make up primary school teachers' attitudes towards using technology in teaching. In the current study we aim to measure these factors. To that end, we developed eight corresponding scales, as well as a scale to measure primary school teachers' use of new technology. Results of the validation study among 659 pre- and in-service teachers showed adequate convergent and discriminant validity for six attitudinal factors and teachers' use of new technology. In addition, we explored the predictive validity of the attitudinal factors for explaining variability in teachers' use of new technology and established configural, metric and scalar measurement invariance.

## 1. Introduction

The importance of teaching young learners to work with new technology to prepare them for their (working) lives in a technology-dominated society has been emphasized by many researchers, educators, and policy makers (International Society for Technology in Education, 2008; Panossian, 2016). Consequently, primary school teachers are expected to use new technology in their teaching. However, meaningful integration of technology by teachers is generally slow (Tondeur et al., 2017). Many teachers use technology to provide classroom instruction (e.g., the interactive whiteboard) and to let students practice routines (e.g., drill-and-practice software) instead of using technology to stimulate children's own analysis, knowledge construction, or problem solving (Ertmer et al., 2015; Smeets, 2020).

Previous work has shown that teachers' attitudes towards technology use may affect the integration of technology in educational practice (e.g., Ottenbreit-Leftwich et al., 2018; Scherer et al., 2018). Although many self-report instruments exist that aim to measure teachers' attitudes towards using technology in their teaching, to our knowledge, a valid and reliable instrument measuring teachers' attitude towards using *new* technology does not yet exist. In addition, current instruments measuring teachers' attitudes towards technology use face several problems. First, a definition of the construct of *attitude* is lacking or incomplete (e.g., Steiner & Mendelovitch, 2017), the subcomponents of attitude that are measured are not explained (e.g., Konca et al., 2016), or a distinction is not made between attitudes and other related concepts such as interest or motivation (e.g., Meishar-Tal & Ronen, 2016). This relates to a second issue, which is that for many instruments the psychometric quality is unclear or not established using statistical validation procedures (e.g., Domingo & Garganté, 2016; Pittman & Gaines, 2015). This is especially problematic, because unless the reliability and validity of an instrument are determined, it is impossible to estimate the value of the results. Third, the object of the attitude is not always clearly defined. For example, researchers have sometimes measured teachers' attitudes towards technology use *in general* (e.g., Christensen & Knezek, 2009; Teo et al., 2017), rather than their attitudes towards using technology *in teaching*.

Some of these problems may be caused by the lack of a strong theoretical basis underlying the development of these instruments. To address this, we have used the well-known Theory of Planned Behaviour (TPB) developed by Ajzen (1991; 2001) to identify and structure underlying factors that make up primary school teachers' attitudes towards using technology in teaching (Wijnen et al., 2021). It seems reasonable to assume that some of these factors are also influential when exploring teachers' attitudes towards using *new* technology in their teaching. We therefore use this theoretical basis to develop an instrument that can be used to measure teachers' attitudes towards using *new* technology in teaching (The TANT questionnaire). New technology is a difficult concept to define and specify. What is new in one context or for one person, might be outdated in another context or for another person. In section 2.2. we explain how we define new technology in this study.

The TANT questionnaire can be used to help us understand why some teachers implement new technology in their teaching, while other teachers might not. Some teachers might think that new technology does not add much to students' learning, which might be a well-substantiated professional opinion, whereas others might not feel capable enough to use new technology, even if they think it might benefit students' learning. Such insights might provide starting points for tailored teacher training programs to support teachers in teaching with new technology. A valid and reliable instrument can be used to evaluate the effects of such training programs on teachers' attitudes towards using new technology.

Furthermore, we added a scale to measure primary school teachers' use of new technology to explore the relationships between the attitudinal factors and teachers' actual new technology use since we still know little about the impact of attitude on teachers' actual use of technology. In a meta-analytic review, Scherer et al., (2020) found that several attitudinal subcomponents influence teachers' intention to use technology. However, there was insufficient evidence to conclude that this intention results in actual use of technology. Using a valid and reliable instrument to measure teachers' attitudes towards new technology and combining this with measures of actual use of new technology might help fill this void in research. Based on the considerations described above, we aim to develop and evaluate the validity and reliability of an instrument that can be used to measure primary school teachers' attitudes towards using new technology in teaching and teachers' actual new technology use.

# 2. Theoretical underpinnings

## 2.1. Theory of Planned Behaviour

According to Ajzen (2001), "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). An attitude-object is the entity about which an attitudinal evaluation is made (Ajzen, 1991, 2001) and is usually a specific behaviour. In this study, the attitude-object is the use of new technology in teaching.

The TPB describes attitude based on three dimensions: (1) *perceptions of behavioural attributes,* refers to (cognitive) beliefs and (affective) feelings someone associates with the specific behaviour, (2) *perceptions of social norms*, refers to the perceived social acceptability of the behaviour; (3) *perceptions of behavioural control*, refers to the perception someone has about the level of control someone has in performing the behaviour. This perception of control can refer to external factors such as availability of time and resources or to internal factors such as the perceived capability of enacting the specific behaviour (often defined as 'self-efficacy' based on Bandura's concept). These dimensions are comprised of factors that are specific for each attitude-object. The evaluation of each of these factors may influence, in various degrees, the overall attitude towards the attitude-object (Ajzen, 1991).

## 2.2. New technology use

The term *new* technology is problematic since something that is new for one person may not necessarily be new for another person. In this study we took the teachers' context and perspectives as a starting point for what could be considered new. 'New' depends on what technology is available to teachers (context), how they perceive that technology can enhance their teaching practice to support student learning and whether they are aware of the potential of different technologies. Dede (2000) already reflected on the capabilities of technology to support teaching and learning, such as mirroring authentic problems or high-tech workplaces (e.g., games, augmented and virtual reality), enhancing students' collaborative skills in online communities of practice (e.g., social media, knowledge forums); modelling and visualization of complex concepts (e.g., simulations, virtual reality) and facilitating the development of higher-order skills through guided inquiry learning (e.g. programming software, simulations, robots). However, most teachers make limited use of these affordances of technology for teaching and learning (Ottenbreit-Leftwich et al., 2018). Studies in the Netherlands (Smeets, 2020; Voogt et al., 2016) showed that teachers mostly used the interactive whiteboard and hardly used other technologies (e.g., robots, virtual reality) to enhance their teaching practices. International research confirms the limited use of new technology by teachers (Fraillon et al., 2018). The results of these studies might indicate that many teachers are not aware of the potential of various technologies to enhance their teaching or are unsure about how such technologies can be used to enhance student learning. This made it hard to define 'new technology' for this study. We decided to focus on the use of technology to enhance teachers' teaching practices and to provide examples of technologies that are currently hardly used by (Dutch) teachers. This resulted in the following explanation of new technology, which we provided to the teachers who completed the TANT questionnaire: "New technology refers to hardware and software that teachers can use to support and/or enrich their teaching practices. Some examples of hardware are: smartphones, tablets, 3D printers and educational robots (BeeBot, DASH). Software examples are: simulation software, design software, programming software and video-editing software."

# 3. Development of the TANT questionnaire

We used Trochim and Donnelly's (2006) framework for construct validity to guide the validation of our questionnaire (see Velayutham et al., 2011 for a detailed description of the application of this framework). Trochim and Donnelly state that a construct must fulfil both translation and criterion validity requirements. Translation validity is determined by content validity (whether the construct is theoretically sound and provides a proper representation of the construct) and face validity (whether the items used to measure the construct clearly reflect the construct and are interpreted as intended by the participants). Criterion validity is determined by convergent validity (whether the items used to measure the same construct are highly correlated with each other), discriminant validity (whether items used to measure different constructs are not correlated with each other), predictive validity (whether the construct is able to predict something it should theoretically be able to predict) and concurrent validity (whether the construct can be used to distinguish between groups that it should theoretically be able to distinguish). This means that an instrument has high construct validity if its content, face, convergent, discriminant, predictive and concurrent validity can be established.

## 3.1 Establishing translation validity

### *3.1.1 Content validity*

As described in the introduction, we used the TPB to develop a theoretical framework that describes factors that make up primary school teachers' attitudes towards using technology in teaching (Wijnen et al., 2021). These factors are perceived usefulness, perceived ease of use, perceived relevance, anxiety, enjoyment, self-efficacy, context dependency and subjective norms. We aim to measure these eight factors with the TANT questionnaire. In addition, we added a scale to measure teachers' actual use of new technology in teaching.

*3.1.1.1. Subscales and items.*

When designing the questionnaire, several previously developed questionnaires that aimed to measure (some of) the subcomponents identified in our theoretical framework were critically reviewed in order to determine whether the items used in those questionnaires would suit our purposes (Admiraal et al., 2017; Christensen & Knezek, 2009, 2017; Heitink et al., 2016; Farjon et al., 2019; Melocchi, 2014; Teo et al., 2016; Van Aalderen-Smeets & Walma van der Molen, 2013).

Based on an exploration of those questionnaires, we selected items that we regarded as suitable to use as a basis for designing our items. When designing questionnaire items several criteria and considerations are important, such as item wording, sequence and format (Schwarz, 2008). Based on these criteria, most of the items that we had selected were adjusted to some extent.

*Perceived usefulness*. Perceived usefulness (PU) refers to teachers' beliefs about the usefulness of new technology for improving and/or enriching their teaching and the learning of their students. We selected four items used by Melocchi (2014) for measuring the component 'perceived usefulness' (Cronbach's a = 0.97). These items were based on the Unified Theory of Acceptance and Use of Technology (UTAUT) instrument (Venkatesh et al., 2003) and are similar to items used by Teo et al. (2016). We revised the original items to better fit the context of our study (using new technology in teaching), to make the items more personal (I think that...) and to address more specific teaching activities. For example, an item used by Melocchi (2014), 'Utilizing iPad technology in my classes improves my job performance', was changed to: 'I think that my students' learning results will improve when I use new technology in my lessons'.

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*Perceived ease of use*. Perceived ease of use (PEU) refers to teachers' beliefs about the ease or difficulty of using new technology in their teaching. We selected three items used by Teo et al. (2016) to measure 'perceived ease of use' (composite reliability = 0.98). We adjusted these items to fit our context and to make the items more strongly worded. For example, the item 'My interaction with technology does not require much effort' was changed to 'I think that the use of new technology in my lessons requires very little effort.'

*Perceived relevance*. Perceived relevance (PR) refers to teachers' beliefs about the importance of using new technology in their teaching to prepare learners for later life. We selected the three items with the highest factor loadings (>0.80) from the scale measuring 'significance' (Cronbach's a = 0.87) in the Teachers' Attitudes towards Computers (TAC) questionnaire (version 6) used by Christensen and Knezek (2009) to measure PR. We adjusted these items to make them more personal and to better fit the context of our study. Furthermore, we expected that most teachers would find the use of new technology at least somewhat relevant. To prevent a ceiling effect, we made the items more strongly worded. A resulting example item is: 'I think it is crucial that students understand the role of new technology in society'.

**Anxiety**. Feelings of anxiety (AX) or fear are known to be important barriers for teachers to use technology in their teaching (Yaghi & Abu-Saba, 1998). We selected three items from the scale measuring 'comfort' (Cronbach's a = 0.88) used by Farjon et al., (2019; see also Christensen & Knezek, 2009) to measure AX. The only change we made to those items was replacing 'ICT' with 'new technology'.

**Enjoyment**. Positive feelings, such as enjoyment (EY), when using technology in teaching may motivate teachers to use technology. We selected four items from the scale measuring 'interest' (Cronbach's a = 0.90) in the TAC questionnaire (version 6) used by Christensen and Knezek (2009) to measure EY. Again, we made some changes to better fit the context of our study and to make the items more personal. For example, an item used by Christensen and Knezek (2009), 'The challenge of learning about computers is exciting', was changed to: 'For me, the use of new technology in my lessons feels like a positive challenge'.

**Self-efficacy**. Self-efficacy (SE) refers to teachers' self-perceived capability to use new technology in their teaching. We selected six items from the 'Technological, Pedagogical, and Content-Knowledge (TPACK)-core questionnaire (Cronbach's a = 0.91) used by Heitink et al. (2016) to measure SE. We adjusted these items in order to make them more strongly worded. For example, instead of using: 'I am able to…', we used 'I am quite able to…'. Furthermore, we replaced 'ICT' with 'new technology'.

**Context dependency**. Context dependency (CD) refers to teachers' *perceptions* that external factors, such as the availability of technical resources, on-site support and available time, are *a prerequisite* for them to be able to use new technology. We used the items measuring 'context-dependency' (Cronbach's a = 0.74) in the context of teaching science and technology (Van-Aalderen-Smeets & Walma van der Molen, 2013) as a basis for the development of items for measuring CD in this study. We adjusted those items to fit the context of this study and to include external factors that have been described as prerequisites for teachers' technology use, such as the availability of ready-made assignments (e.g., Vatanartiran & Karadeniz, 2015) and technical support (e.g., Khanlari, 2016).

**Subjective norms**. Subjective norms (SN) refer to teachers' perceptions as to whether other people who are important to that teacher think it is good or bad to use new technology in teaching. These important others can be colleagues, the school administration, parents, or students. We selected four items to measure 'subjective norms' (Cronbach's a = 0.89) as used by Admiraal et al. (2017). We adjusted these items to make them more personal (I have the feeling that…) and replaced 'ICT' with "new technology'.

**Actual use**. To determine whether a teacher's attitude towards using new technology is related to actual technology use, we added a separate section to measure teachers' self-reported use of new technology in their teaching. This scale contained seven items; responses to these items were given on a 7-point Likert scale: (1) never, (2) a few times a year, (3) once a month, (4) a few times a month, (5) once a week, (6) several times a week, (7) every day (see table 1).

### *3.1.2. Likert scale*

Although there are several possibilities for measuring attitudes, we chose to develop a Likert-scale instrument, because such instruments have several benefits. First, they are suitable when including items organized in multiple subscales. Second, they can easily be distributed to a large group of participants. Third, the questions can be answered easily. Last, Likert scales allow parametric testing.

For the attitudinal scales, we used a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. There is some criticism of using a Likert scale with an uneven number of response options (Johns, 2010) due to the difficulty of determining how participants interpret the midpoint of such a scale. This midpoint can be interpreted as: do not agree/do not disagree, neutral, no opinion, or do not know. Therefore, some argue for only using an even number of response options, thereby forcing participants to make a choice. However, forcing participants to make a choice may lead to skewed results. To avoid skewed results, we decided to use a 5-point Likert scale in which we labelled only the two extremes (strongly disagree–strongly agree), thereby presenting the response options as a sliding scale.



## 3.2. Face validity

The first version of the TANT questionnaire, containing 39 items, was presented to five primary school teachers who evaluated every item on clarity and understandability in extended interviews. Furthermore, they indicated to what extent they considered the items appropriate for measuring the underlying constructs and they were asked to indicate whether any additional items were necessary. Based on these evaluations we made several changes. The most important one was reversing the items for the subscale 'perceived ease of use'. Instead of using items such as: 'I think it is very easy to use new technology in my lessons', the items were changed to: 'I think it is very difficult to use new technology in my lessons'. This was done because some of the teachers indicated that they felt their colleagues might perceive the use of new technology as difficult instead of easy, and that reversing the items would better fit their views. Furthermore, we added two items to the subscale 'context dependency'. These items represented two other external factors that teachers might perceive as prerequisites for the use of new technology: support from colleagues and that every student has their own device.

# 4. Investigating criterion validity

## 4.1. Participants

The questionnaire (34 attitude items and 7 actual use items) was administered to a large group of pre- and in-service primary school teachers (*N* = 659) in the Netherlands. This group consisted of 257 in-service primary school teachers and 402 third- and fourth-year pre-service teachers. The effective sample size consisted of 136 (20.6%) males and 523 (79.4%) females. Participants' age ranged from 18 to 65 years old (*M* = 29.52, *SD* = 12.69).

## 4.2. Procedure

After approval by the ethical committee from the university of the first author, the questionnaire was administered. One of the researchers visited the primary schools (for in-service teachers) and teacher education colleges (for pre-service teachers). After a brief introduction and giving informed consent, teachers were directed to an online (84.2%) or paper-and-pencil version (15.8%) of the questionnaire, which took approximately 15 minutes to complete. Individual clarification was given if a participant did not understand a specific item.

Approximately 92.5% of the data were collected in this way. In a few cases, having the researcher visit the school was not possible. Therefore, a small number of participants received a link by email redirecting them to the online version of the questionnaire, which they completed on their own.

## 4.3. Data analysis

We used similar steps as Post and Walma van der Molen (2019) to explore the construct validity and reliability of the TANT questionnaire. First, we looked at the amount of missing data and investigated the range of responses and standard deviation of participants' scores for each item. Next, we conducted an exploratory factor analysis (EFA) with half of the data in our sample in MPlus (Muthén & Muthén, 1998-2015). This approach helped us identify latent factors underlying teachers' attitudes towards using new technology in a data-driven way. As a next step, with the other half of the sample, we performed a confirmatory factor analysis (CFA) to test the model fit of the factor structure we found with EFA, again using MPlus.

The two subsamples that were used for the EFA and CFA (subsample A, *n* = 328 and subsample B, *n* = 331) were randomly extracted from the dataset, using the split file option in SPSS. In order to determine whether the subsamples were equivalent regarding the distribution of pre- and in-service teachers and the gender of the participants, chi-square tests were used. We chose to evaluate equivalence for these two variables, because Drossel et al., (2017) found that experience with using ICT in teaching and gender impact teachers' technology use in the Netherlands.

Results indicated that pre- and in-service teachers ($\chi^2$ = .426, $p$ = .514) and males and females ($\chi^2$ = .505, $p$ = .477) were equally distributed across both subsamples.

## 5. Results

### 5.1. Preliminary data checks

In subsample A, 0.2% of the data were missing, and in subsample B it was 0.3%. In the online version of the questionnaire, we used a 'forced response' option. This meant that participants had to respond to all items to complete the questionnaire. This was not the case for the paper-and-pencil version of the questionnaire but only a few participants did not answer one or more items in the paper-and-pencil version of the questionnaire. Since the percentages of missing data in our samples are very low, we did not conduct any additional analyses of our missing data. Both the EFA and CFA were performed using the raw data from both subsamples, including the missing data. We used the default option for handling missing data in MPlus.

Next, we calculated the standard deviation and range of responses for each item. The standard deviations should hover around 1.0 for a five-point Likert scale and each response option should be used at least once (Coulson, 1992). Standard deviations ranged from .807 to 1.154 and all response options were used at least once for all items with a five-point Likert scale. For the 7-point Likert scales (self-reported behaviour), standard deviations ranged from 1.032 to 1.418 and again all response options were used at least once. The data were considered appropriate for factor analyses.

### 5.2. Exploratory factor analysis

Using subsample A, iterative exploratory factor analyses were conducted to explore the factor structure of the attitudinal factors. We used maximum likelihood (ML) estimation, and since we expected the subscales to correlate, Geomin oblique rotation was used (Field, 2009). Items were deleted from further EFA's if they showed a factor loading below 0.35 or cross loadings less than 0.15 from their greatest factor loading (Worthington & Whittaker, 2006).

Four items developed to measure context dependency, two items to measure perceived usefulness and three items developed to measure enjoyment were deleted, due to low factor loadings or cross loadings. This resulted in only one item left to measure enjoyment. Since a factor cannot be represented by one item, this item was deleted, resulting in the elimination of the enjoyment factor. After removing problematic items, the EFA analysis revealed a six-factor structure (with enjoyment omitted), where a seven-factor structure had been anticipated.

Inspection of the factor loadings revealed that items developed to measure 'perceived ease of use' and 'anxiety' loaded together on one factor. When reviewing the items, this made sense because items from both factors were aimed at measuring negative aspects of new technology use. We therefore renamed this factor 'perceived difficulty'. This resulted in the identification of the following six factors: perceived relevance (Eigenvalue 3.116), perceived usefulness (Eigenvalue 1.297), perceived difficulty (Eigenvalue 5.958), self-efficacy (Eigenvalue 2.327), context dependency (Eigenvalue 1.107), and subjective norms (Eigenvalue 1.704).

In addition, we conducted an EFA to explore the factor structure of the 'new technology use' factor. We again used ML estimation and Geomin oblique rotation. Result of the EFA showed a one-factor structure (Eigenvalue 3.576) with factor loadings ranging from 0.586 to 0.753. Table 1 presents the observed factors of the TANT questionnaire.

## 5.3. Confirmatory factor analysis

### *5.3.1. Attitudinal factors*

We performed CFA with ML estimation to determine how well the data from subsample B fit the six-factor solution we identified with EFA. Several goodness-of-fit indices were used to determine model fit. These indices are standardized root-mean-square residual (SRMR), comparative fit index (CFI), Tucker-Lewis index (TLI), and the root-mean-square error of approximation (RMSEA). To indicate good fit, SRMR should be below 0.08 (Prudon, 2015) and CFI and TLI should exceed .95. Furthermore, RMSEA values should be below 0.07, where lower values are indicative of better fit (Hooper, Coughlan, & Mullen, 2008). Since the $\chi^2$ test has some shortcomings (see Hooper et al., 2008; Prudon, 2015) we only report the $\chi^2$ results for completeness. It should be noted that the above thresholds are used as guidelines and not as strict rules (Prudon, 2015).

Furthermore, we calculated the average variance extracted (AVE), average shared variance (ASV), maximum shared variance (MSV) and composite reliability (CR) for each subscale as obtained by CFA to further estimate the discriminant and convergent validity (Carter, 2016; Raykoff, 1997). Discriminant validity of a subscale is considered satisfactory when the AVE is greater than or equal to 0.50 and also greater than the ASV and MSV of the factor. For convergent validity, the CR value should be equal or greater than 0.70 and greater than the AVE of the subscale (Fornell & Larcker, 1981).

Results of the CFA for the attitudinal factors were somewhat mixed. The absolute fit indices indicated adequate to good fit (SRMR = 0.060, RMSEA = 0.066, $\chi^2$ = 577.713, $df$ = 237, $p$ < 0.001), but the incremental fit indices indicated poor fit (CFI = 0.890, TLI = 0.872). According to Hooper et al. (2008) the absolute fit indices "provide the most fundamental indication of how well the proposed theory fits the data" (p. 53), because unlike incremental fit indices their calculation does not rely on a comparison with a baseline model, but instead considers how well the model fits the data in comparison to no model at all.

Furthermore, the baseline model that is used for calculating incremental fit indices has the null hypothesis that all variables are uncorrelated (Hooper et al., 2008). Inspection of the correlation tables showed that the variables in the TANT questionnaire *are* correlated, ranging from $r = 0.238$ to $r = 0.702$. Therefore, we used the absolute fit indices (RMSEA, SRMR and $\chi^2$) as the most important indicators for determining model fit.

The factor PU is represented by two items. Although it is generally agreed that three or more items should represent a factor, the use of two items is considered acceptable if the items are reasonably strongly correlated with each other (Eisinga et al., 2013) using the Spearman-Brown correlation. The two items for measuring PU were reasonably inter-correlated, $\rho = 0.70$. Therefore, the factor PU was included.

Composite reliability scores for all factors were above the threshold of .70 and exceeded the AVE scores for each respective subscale, indicating good internal consistency of the scales. Furthermore, AVE scores exceeded the ASV and MSV scores for each respective subscale, indicating good discriminant power of the scales (Table 2).

In addition, we calculated the correlations between the attitudinal factors in order to gain insight into the relationships between these factors. The correlation matrix (Table 2) shows that PR was strongly positively correlated with PU. This makes sense, because one can imagine that a teacher who is enthusiastic about the usefulness of new technology for teaching also wishes to teach their pupils how to use new technology so that they can benefit from it in later life.

Furthermore, PD had a moderately negative correlation with SE. This also makes sense, because perceptions of the difficulty of using the technology are likely to be related to self-efficacy for using new technology. Next, PD was moderately positively correlated with CD. It makes sense that perceptions about the difficulty of using technology in teaching may be related to the degree of support that teachers feel they need. Lastly, SE was moderately negatively correlated with CD. Again, one can imagine that a teacher with high SE in the use of new technology feels that they do not need much support (CD), or vice versa.

### *5.3.2. New technology use*

To determine the model fit of the 'new technology use' scale, we conducted a CFA, using subsample B. Except for the RMSEA, which was slightly above the threshold, results of the CFA indicated good fit ($\chi^2 = 43.215$, $df = 14$, $p < 0.001$, RMSEA = 0.08, SRMR = 0.033, CFI = 0.962, TLI = 0.942). The factor 'new technology use' had

**Table 1** Factor structure for the TANT questionnaire

| Item |
|---|
| I think it is crucial that students understand the role of new technology in society |
| I think it is very important for students' future that they get the opportunity to learn how to work with new technology at school |
| I think it is essential that students learn how to work with new technology at school, so that they are well prepared for societal developments |
| I think that, with the help of new technology, I can provide more variety in the assignments I offer my students |
| I think that, with the help of new technology, I can more easily differentiate in how I offer the content to be learned |
| I get a sinking feeling when I have to do something new with new technology in my lessons |
| I feel nervous about the idea of using new technology in my lessons |
| I feel tense when I have to use new technology in my lessons |
| I think it requires a lot of effort to use new technology in my lessons |
| I think it is very difficult to use new technology in my lessons |
| I think it is difficult to use new technology in my lessons in the way that I want |
| I am well aware of the new technologies that I can use in the subjects I teach |
| I know exactly how I can use new technologies to present concepts from the subject I am teaching in a different way |
| I am quite able to choose new technologies that enhance my students' learning process |
| I am quite able to choose new technologies that enhance the pedagogy in my lessons |
| I am quite able to choose new technologies that support the lesson content for the subjects I teach |
| I am quite able to provide lessons that appropriately combine content, technology and pedagogy |
| For me, the availability of a training program determines whether I use new technology in my lessons |
| For me, the availability of technical support determines whether I use new technology in my lessons |
| For me, the availability of content support, in the form of an ICT-coordinator, determines whether I use new technology in my lessons |
| I have the feeling that new technology has an important place in education at our school |
| I have the feeling that there is a clear vision about using new technology in education at our school |
| I have the feeling that using new technology in lessons is appreciated by colleagues and administration at our school |
| I have the feeling that my colleagues consider the use of new technology in education to be important |
| How often do students use new technology to work on challenging problems (such as designing gymnastics gear) in your lessons? |
| How often do students use new technology to make a product (such as a blog, vlog or website) in your lessons? |
| How often do students use new technology to present to each other what they have learned (such as presentation software, movies, or animations) in your lessons? |

| EFA | | | | | | | CFA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PR | PU | PD | SE | CD | SN | USE | PR | PU | PD | SE | CD | SN | USE |
| 0.606 | | | | | | | 0.691 | | | | | | |
| 0.824 | | | | | | | 0.752 | | | | | | |
| 0.808 | | | | | | | 0.749 | | | | | | |
| | 0.726 | | | | | | | 0.777 | | | | | |
| | 0.727 | | | | | | | 0.690 | | | | | |
| | | 0.689 | | | | | | | 0.736 | | | | |
| | | 0.908 | | | | | | | 0.876 | | | | |
| | | 0.755 | | | | | | | 0.714 | | | | |
| | | 0.527 | | | | | | | 0.625 | | | | |
| | | 0.644 | | | | | | | 0.718 | | | | |
| | | 0.539 | | | | | | | 0.581 | | | | |
| | | | 0.614 | | | | | | | 0.615 | | | |
| | | | 0.668 | | | | | | | 0.709 | | | |
| | | | 0.695 | | | | | | | 0.775 | | | |
| | | | 0.818 | | | | | | | 0.743 | | | |
| | | | 0.769 | | | | | | | 0.723 | | | |
| | | | 0.677 | | | | | | | 0.684 | | | |
| | | | | 0.350 | | | | | | | 0.550 | | |
| | | | | 0.459 | | | | | | | 0.652 | | |
| | | | | 0.966 | | | | | | | 0.736 | | |
| | | | | | 0.695 | | | | | | | 0.719 | |
| | | | | | 0.698 | | | | | | | 0.674 | |
| | | | | | 0.634 | | | | | | | 0.643 | |
| | | | | | 0.753 | | | | | | | 0.681 | |
| | | | | | | 0.586 | | | | | | | 0.630 |
| | | | | | | 0.753 | | | | | | | 0.771 |
| | | | | | | 0.679 | | | | | | | 0.729 |

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**Table 1** Continued

| Item |
|---|
| How often do students use new technology to delve into a subject that interests them (such as making an animation in Scratch about the eruption of a volcano) in your lessons? |
| How often do you use new technology to connect learning in school with learning outside of school (such as a museum visit or environmental research)? |
| How often do you use new technology to get students to collect and analyse data (such as sensors or apps on a smartphone) in your lessons? |
| How often do students use new technology for programming in your lessons? |

Notes:

a. Exploratory factor analysis (EFA) conducted with maximum likelihood (ML) estimation and geomin rotation with subsample A, $N$ = 327. Values represent factor loadings.
b. Confirmatory factor analysis (CFA) conducted with maximum likelihood (ML) estimation and geomin rotation with subsample B, $N$ = 332. Values represent factor loadings.
c. Only factor loadings > .35 are displayed.
d. PR = Perceived relevance, PU = Perceived usefulness, PD = Perceived difficulty, SE = Self-efficacy, SN = Subjective norms, USE = New technology use.
e. For USE an EFA and CFA was conducted separately.
f. The items used were originally in Dutch. This table presents the English translations of those items, which are checked by a native English speaker.

sufficient convergent and discriminant power as shown by the AVE score of 0.65 and CR score of 0.81, which exceeded the 0.5 and 0.7 thresholds, indicating that this is a clear distinguishable factor. Furthermore, we explored to what extent the factor ‘new technology use’ was correlated with the attitudinal factors. Results from these correlation analyses showed that all attitudinal factors were significantly correlated with new technology use (see Table 2).

## 5.4. Predictive validity

We performed regression analyses for each independent variable to investigate whether scores on the subscales had an impact on teachers’ self-reported use of new technology in their teaching. For these analyses we used all data. As can be seen from Table 3, each independent variable has a significant impact on teachers’ self-reported new technology use. However, only self-efficacy explained a reasonable amount of the variance in teachers’ new technology use ($R^2$ = 0.193).

| | EFA | | | | | | | CFA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PR | PU | PD | SE | CD | SN | USE | PR | PU | PD | SE | CD | SN | USE |
| | | | | | | | 0.751 | | | | | | | 0.759 |
| | | | | | | | 0.606 | | | | | | | 0.539 |
| | | | | | | | 0.616 | | | | | | | 0.538 |
| | | | | | | | 0.588 | | | | | | | 0.630 |



## 5.5 Concurrent validity

A prerequisite for determining concurrent validity is the expectation, based on theory, that, in this context, different groups of teachers have different attitudes towards the use of new technology in teaching. If such differences exist, one should be able to distinguish between these groups based on the scores of the participants on the instrument. In our study, we included two groups: pre- and in-service primary teachers.

However, only a few studies have compared the attitudes of pre- and in-service teachers towards the use of technology in their teaching. For example, Teo (2015) measured several attitudinal factors (PU, PEU, SN, SE) among pre- and in-service teachers. He found that pre-service teachers had higher mean scores on these factors than in-service teachers, but this difference was not significant. Similarly, Mai (2014) and Agyei and Voogt (2011) found no significant differences between pre- and in-service teachers' attitudes towards using technology. These results seem to indicate that there are no significant differences in attitudes between pre- and in-service teachers. To evaluate whether the TANT questionnaire is a suitable instrument to study differences between pre- and in-service teachers' attitudes towards using new technology, because both groups interpret the items and response scales in the same way, we evaluated the measurement invariance of the TANT questionnaire.

**Table 2** Factor correlations, CR, AVE, MSV, and ASV for the TANT questionnaire subscales ($N$ = 332)

| | Perceived relevance | Perceived usefulness | Perceived difficulty | Self-efficacy | Subjective norms | Context dependency | New technology use |
|---|---|---|---|---|---|---|---|
| Perceived relevance | | 0.702* | -0.233* | 0.268* | 0.353* | 0.154* | 0.231* |
| Perceived usefulness | | | -0.405* | 0.521* | 0.281* | 0.053 | 0.209* |
| Perceived difficulty | | | | -0.574* | -0.158* | 0.445* | -0.337* |
| Self-efficacy | | | | | 0.236* | -0.488* | 0.433* |
| Subjective norms | | | | | | 0.105 | 0.224* |
| Context dependency | | | | | | | -0.299* |
| Composite reliability (CR) | 0.77 | 0.70 | 0.86 | 0.86 | 0.77 | 0.72 | 0.81 |
| Average variance extracted (AVE) | 0.67 | 0.67 | 0.64 | 0.63 | 0.59 | 0.59 | 0.65 |
| Average shared variance (ASV) | 0.15 | 0.16 | 0.15 | 0.15 | 0.06 | 0.09 | - |
| Maximum shared variance (MSV) | 0.49 | 0.49 | 0.33 | 0.33 | 0.12 | 0.24 | - |

* Factor correlation is significant at $p < 0.05$

**Table 3** Regression analyses per variable ($N$ = 659)

| | *B* | *SD* | *t* | *p* | $R^2$ |
|---|---|---|---|---|---|
| Perceived relevance | 0.115 | 0.047 | 2.461 | 0.014 | 0.013 |
| Perceived usefulness | 0.125 | 0.051 | 2.444 | 0.015 | 0.016 |
| Perceived difficulty | -0.235 | 0.043 | -5.501 | < 0.001 | 0.055* |
| Self-efficacy | 0.439 | 0.038 | 11.497 | < 0.001 | 0.193* |
| Context dependency | -0.178 | 0.049 | -3.610 | < 0.001 | 0.032 |
| Subjective norms | 0.188 | 0.046 | 4.038 | < 0.001 | 0.035* |

*Significant at $\alpha < 0.05$

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### *5.5.1 Measurement invariance*

*Attitudinal factors.* We conducted a multiple-group CFA to test the measurement invariance of the attitudinal factors (for a more in-depth explanation of measurement invariance, see Chen, 2007). We explored configural invariance (i.e., similarity of the factor structures), metric invariance (i.e., similarity of factor loadings) and scalar invariance (i.e., similarity of factor intercepts) using the total respondent sample ($N$ = 659).

In order to determine invariance, differences in $\chi^2$ (i.e., $\Delta\chi^2$) between the different analyses (configural, metric, and scalar) are explored. However, because $\chi^2$ is sensitive to sample size and model assumptions (e.g., linearity, multivariate normality; Byrne et al., 1989) we only report $\Delta\chi^2$ for completeness. Cheung and Rensvold (2002) recommended using the ΔCFI. In addition, Chen (2007) recommended evaluating changes in RMSEA (ΔRMSEA) and SRMR (ΔSRMR) as well. For establishing metric invariance, ΔCFI $\leq$-0.01, ΔRMSEA $\leq$0.015 and ΔSRMR $\leq$0.03 indicate invariance. For scalar invariance, the ΔSRMR is different and should be $\leq$0.01. To establish metric invariance, fit indices of the metric invariance model were compared with fit indices of the configural invariance model. To establish scalar invariance, fit indices of the scalar invariance model were compared with fit indices of the metric invariance model.

As can be seen from Table 4, fit indices for the configural model indicated acceptable fit. Furthermore, the metric and scalar Δ-indices were all below the recommended thresholds, indicating metric and scalar invariance. Therefore, we conclude that the attitudinal factors measured with the TANT questionnaire may be used to compare scores from pre- and in-service teachers.

**Table 4** Measurement invariance analysis for the attitudinal factors

| | $\chi^2$ | *df* | CFI | RMSEA | SRMR | $\Delta\chi^2$ | p | ΔCFI | ΔRMSEA | ΔSRMR |
|---|---|---|---|---|---|---|---|---|---|---|
| Configural invariance | 1007.15 | 474 | 0.910 | 0.058 | 0.059 | - | - | - | - | - |
| Metric invariance | 1035.28 | 492 | 0.909 | 0.058 | 0.062 | 28.129 | 0.060 | 0.001 | 0.000 | 0.003 |
| Scalar invariance | 1093.70 | 510 | 0.902 | 0.059 | 0.064 | 58.412 | < .001 | 0.007 | 0.001 | 0.002 |

Groups compared: pre-service teachers (*N* = 402) vs. in-service teachers (*N* = 257).

*New technology use.* To test measurement invariance for 'new technology use' we again performed a multiple-group CFA. As can be seen from Table 5, most fit indices for the configural model indicated acceptable fit. However, RMSEA was above the recommended threshold of 0.07. To explore whether partial invariance could be established, we evaluated whether omission of one or more items resulted in a better fit of the configural model. Removing item 5: 'How often do you use new technology to connect learning in school with learning outside of school (such as a museum visit or environmental research)?' resulted in a better fit for the configural model. However, ΔCFI for scalar invariance was still above the recommended threshold if item 5 was omitted. We therefore conclude that configural and metric invariance could be established for new technology use if item 5 was excluded, but scalar invariance could not. Therefore, comparing pre- and in-service teachers' scores on new technology use should be done with care.



### *5.5.2. Primary school teachers' scores*

To gain insight into the scores of pre- and in-service primary school teachers on the factors of the TANT questionnaire, we calculated the unweighted average scores for each attitudinal factor (see Table 6). These results indicate that overall, pre- and in-service primary school teachers regarded it relevant to use new technology in their teaching to prepare students for their later life (above midpoint 3), believed new technology is a beneficial tool for teaching, viewed the use of new technology in their teaching as not very difficult, had somewhat low feelings of self-efficacy, felt somewhat dependent on contextual factors and felt that their social environment is neutral about the use of new technology in teaching.

Both pre- and in-service teachers use new technology most often for letting students present to each other what they have learned. In-service teachers' use new technology the least for letting students collect and analyse data and pre-service teachers use new technology the least for letting students do programming. Their self-reported use indicates that, overall, they used new technology in their teaching only a few times a year (see table 7).

**Table 5** Measurement invariance analysis for new technology use

| | $\chi^2$ | *df* | CFI | RMSEA | SRMR | $\Delta\chi^2$ | p | ΔCFI | ΔRMSEA | ΔSRMR |
|---|---|---|---|---|---|---|---|---|---|---|
| Configural invariance | 98.78 | 28 | 0.952 | 0.088 | 0.037 | - | - | - | - | - |
| Metric invariance | 114.18 | 34 | 0.946 | 0.085 | 0.052 | 15.398 | 0.017 | 0.001 | 0.003 | -0.015 |
| Scalar invariance | 148.98 | 40 | 0.926 | 0.091 | 0.059 | 34.806 | < .001 | 0.020 | 0.006 | 0.007 |
| ***Excluding item 5*** | | | | | | | | | | |
| Configural invariance | 38.36 | 18 | 0.983 | 0.059 | 0.026 | - | - | - | - | - |
| Metric invariance | 49.93 | 23 | 0.978 | 0.060 | 0.043 | 11.569 | 0.041 | 0.005 | 0.001 | -0.017 |
| Scalar invariance | 84.15 | 28 | 0.954 | 0.078 | 0.052 | 34.217 | <.001 | 0.024 | -0.018 | -0.009 |

Groups compared: pre-service teachers (*N* = 402) vs. in-service teachers (*N* = 257).

**Table 6** Unweighted average scores for each attitudinal component

| | pre- and in-service teachers (*N* = 659) | | in-service teachers (*N* = 257) | | pre-service teachers (*N* = 402) | |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| Perceived relevance | 4.01 | 0.677 | 4.20 | 0.725 | 3.90 | 0.674 |
| Perceived usefulness | 3.75 | 0.736 | 3.94 | 0.778 | 3.63 | 0.729 |
| Perceived difficulty* | 2.58 | 0.784 | 2.49 | 0.785 | 2.63 | 0.780 |
| Self-efficacy | 2.78 | 0.702 | 2.69 | 0.725 | 2.83 | 0.681 |
| Context dependency* | 3.22 | 0.838 | 3.39 | 0.889 | 3.11 | 0.787 |
| Subjective norms | 3.13 | 0.772 | 3.45 | 0.673 | 2.93 | 0.765 |

Notes:
a. A lower score indicates a more positive attitude

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**Table 7** Mean scores on new technology use items

| Item number | | pre- and in-service teachers (*N* = 652) | | in-service teachers (*N* = 254) | | pre-service teachers (*N* = 398) | |
|---|---|---|---|---|---|---|---|
| | | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| 1 | Work on challenging problems | 2.29 | 1.418 | 2.25 | 1.585 | 2.32 | 1.302 |
| 2 | Product making | 1.98 | 1.197 | 1.66 | 1.13 | 2.18 | 1.196 |
| 3 | Presenting | 2.53 | 1.409 | 2.26 | 1.421 | 2.70 | 1.376 |
| 4 | Delving into a subject | 2.15 | 1.373 | 1.88 | 1.391 | 2.33 | 1.335 |
| 5[b] | Connecting | 2.03 | 1.032 | 1.87 | 1.071 | 2.14 | 0.995 |
| 6 | Collecting and analysing data | 1.98 | 1.363 | 1.57 | 1.176 | 2.23 | 1.413 |
| 7 | Programming | 1.87 | 1.128 | 1.80 | 1.229 | 1.92 | 1.058 |
| | *Overall technology use* | 2.12 | 0.913 | 1.90 | 0.925 | 2.26 | 0.878 |

Notes:
a. Measured on a 7-point Likert scale: (1) never, (2) a few times a year, (3) once a month, (4) a few times a month, (5) once a week, (6) several times a week, (7) every day.
b. Although we report the mean and SD for this item, scores between pre- and in-service teachers may not be compared because configural invariance could not be established for item 5.

## 6. Conclusion and discussion

The goal of this study was to develop and evaluate the validity and reliability of an instrument that can be used to measure primary school teachers' attitudes towards using new technology in teaching and teachers' actual new technology use. In an earlier study (Wijnen et al., 2021) we identified several attitudinal factors that make up this attitude and we aimed to measure these attitudinal factors with the TANT questionnaire. The results of our analyses show that the construct validity and reliability for the factors perceived relevance, perceived usefulness, perceived difficulty, self-efficacy, context-dependency, and subjective norms can be supported. Furthermore, our correlation analyses and additional analyses of variance show that although these factors are related, they represent conceptually different constructs. Based on these results we conclude that the TANT questionnaire is a valid and reliable instrument that can be used to gain insight into why some teachers implement new technology in their teaching, while other teachers might not. This might provide starting points for tailored teacher training. Furthermore, the TANT questionnaire can be used to evaluate the effects of teacher training programs on teachers' attitudes towards new technology use.

In the TANT questionnaire we included an additional scale to measure teachers' actual use of new technology. Results showed that 'new technology use' is a clearly distinguishable factor that can be measured reliably. We added this scale because we agree with Scherer et al. (2020) that it is important to explore to what extent attitudinal factors impact teachers actual use of technology. In our study, we conducted regression analyses to explore the impact of each attitudinal factor as an impact on teachers' actual use of new technology. Although such regression analyses are not enough to claim causality, we found that all factors had a significant impact on teachers' actual use of new technology, which might indicate that these attitudinal factors are important to consider if we wish to learn what motivates or discourages teachers to use new technology in their teaching.

Furthermore, the attitudinal factors of the TANT questionnaire demonstrated full configural, metric and scalar invariance for pre- and in-service primary school teachers. This means that scores on the TANT questionnaire from both groups may be compared. This is valuable, since there are few studies that explore differences in attitude towards using technology between pre- and in-service primary school teachers.

Despite the average to high scores on the attitudinal factors, both pre- and in-service teachers indicated to make very little use of new technology. A possible explanation may be found in the relatively low scores on self-efficacy, which according to our regression analysis was the factor that explained the most variance in new technology use (19.3%).

The low reported use of new technology could also be caused by the way new technology use was measured in this study. The items do not solely reflect teachers' self-reported use of new technology but include statements about the *way* new technology is used. For example, the item: 'How often do you use new technology to get students to collect and analyse data (such as sensors or apps on a smartphone) in your lessons?' does not only reflect the use of new technology but also how often teachers let their students collect and analyse data. If a teacher does not let their students collect and analyse data (with or without new technology), the score on this item will be low.

Furthermore, other external factors (such as time and resources) might prevent teachers from using new technology (Khanlari, 2016; Francom, 2020). We aimed to measure teachers' perceptions regarding such factors with the factor context-dependency. However, the factor analyses revealed cross-loadings and therefore several of the initially developed items were removed. As a result, we only analysed the results of teachers' views regarding their dependency on training and support. In Appendix A, we propose several new items that might be used to expand the factor context-dependency to include teachers' views regarding their dependency on other factors.

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## 6.2. Limitations and future research

The current version of the TANT questionnaire is in Dutch. Although we carefully translated the items into English for this article (checked by a native speaker), cross-cultural validation should determine the construct validity of the TANT questionnaire in different countries.

Furthermore, the explanation of *new* technology in the TANT questionnaire, might not be suitable for other contexts, since the examples of hardware and software we provided might not fit other contexts We therefore urge users of the TANT questionnaire to adapt these examples to their context.

As a next step, we intend to explore whether the TANT questionnaire can be used to identify different groups of teachers, based on their attitudes towards using new technology in teaching. This allows us to identify possible barriers that certain groups of teachers experience or perceive when they implement new technology in their teaching. Identification of such barriers may provide useful starting points for the development of tailored teacher training programs that fit the needs of different groups of teachers.

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# Appendix A: Potential items to expand the 'context-dependency' scale

- For me, the availability of more time determines whether I use new technology in my lessons
- For me, the availability of extra technological equipment determines whether I use new technology in my lessons
- For me, the availability of a training on technology integration determines whether I use new technology in my lessons

3

# 4

# Measuring primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and validation of the SHOT questionnaire

This chapter is based on: Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2021). Measuring primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and validation of the SHOT questionnaire. *Thinking Skills and Creativity, 42*. https://doi.org/10.1016/j.tsc.2021.100954

## Abstract

This paper describes the development and validation of a new instrument to measure primary school teachers' attitudes towards stimulating higher-order thinking in students (SHOT questionnaire). It is believed that it is necessary to explicitly teach students to think, because it cannot be assumed that students will automatically become good thinkers. Therefore, teachers are expected to stimulate students to engage in higher-order thinking. However, we know little about teachers' attitudes towards teaching practices that engage students in higher-order thinking. Therefore, we need a valid and reliable measurement instrument that can be used to measure teachers' attitudes towards stimulating higher-order thinking (SHOT). Hence, we developed the SHOT questionnaire. Based on an earlier literature review, we identified four attitudinal factors that we aimed to measure with the SHOT questionnaire. In addition, we included a scale to measure teachers' behaviour aimed at stimulating higher-order thinking. Results of the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) with 659 pre- and in-service primary school teachers' show that the requirements for construct validity were met. Furthermore, we found that in-service teachers, who are more positive about the relevance of stimulating higher-order thinking and their ability to do this, encourage students significantly more often to engage in higher-order thinking than pre-service teachers do.

## 1. Introduction

This paper presents a validation study of a questionnaire to measure primary school teachers' attitudes towards Stimulating Higher-Order Thinking in students (the SHOT questionnaire). Higher-order thinking skills, such as critical thinking, creative thinking, and problem solving are regarded as crucial, already at the primary school level, for students to develop in order to prepare them for their later (working) lives and are therefore mentioned in many models regarding 21st-century learning (OECD, 2018; Voogt & Pareja Roblin, 2012; World Economic Forum, 2016). Moreover, by engaging in higher-order thinking, students actively construct knowledge and engage in meaningful learning (Anderson et al., 2001). With the use of higher-order thinking, students are better able to make sense of what they learn, connect what they learn with previously acquired knowledge and store new knowledge in their long-term memory. This allows them to apply what they learned in new situations more easily (transfer of knowledge) (Anderson et al., 2001).

It is believed that it is necessary to explicitly teach students to think in such ways, because it cannot be assumed that students will automatically become good thinkers (Elder, 2003). Therefore, teachers are expected to stimulate students to engage in higher-order thinking. This means that teachers offer assignments in which students use complex cognitive skills (e.g., analysing, evaluating, creating) in order to find a solution or make a decision, prediction, judgement or product. However, primary school teachers mostly engage in teaching practices aimed at stimulating *lower*-order thinking skills, with an emphasis on knowledge transfer and there is little evidence that higher-order thinking is systematically stimulated and assessed in schools (Schulz & FitzPatrick, 2016).

Previous work has shown that teachers' *attitude* towards specific teaching practices impact teachers' classroom behaviour (e.g., Stipek et al., 2001; Van Aalderen-Smeets & Walma van der Molen 2015). However, we know little about teachers' attitudes towards teaching practices that engage students in higher-order thinking, especially when it concerns primary school teachers (Schulz & FitzPatrick, 2016). Do teachers believe it is important to stimulate higher-order thinking? Do teachers feel capable when stimulating such thinking? In order to support teachers, it is important that we gain an understanding of teachers' attitudes regarding this teaching behaviour. In order to do that, we need a valid and reliable measurement instrument that can be used to measure teachers' attitudes towards stimulating higher-order thinking. Furthermore, such an instrument can be used to investigate, monitor, and evaluate the effects of teacher training programs aimed at developing more positive teacher attitudes. To our knowledge, however, no such instrument yet exists. Therefore, the goal of this study was to develop and validate such an instrument.

# 2. Theoretical underpinnings

## 2.1. Focus on attitude

Attitude is "probably one of the most important concepts in psychology" (Gawronksi & Bodenhausen, 2007, p. 687), because (1) a person's attitude towards a particular object may impact a person's behaviour towards that object, (2) it influences how a person processes information regarding the attitude-object, and (3) it is possible to influence attitudes with educational efforts (Vogel & Wänke, 2016).

In this study, we used the well-known Theory of Planned Behaviour (TPB) developed by Ajzen (1991; 2001) to define attitude. According to Ajzen (2001) "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). The object about which an attitudinal evaluation is made is called an attitude-object. In this study, the attitude-object is 'stimulating higher-order thinking in students'.

Based on the TPB, we view attitude as an 'umbrella-term' consisting of three dimensions that, together, form a persons' attitude. The first dimension, *perceptions of behavioural attributes,* represents beliefs and feelings a person associates with a specific attitude-object. The second dimension, *perceptions of the social norm*, represents a person's perception of the social acceptability of the behaviour. The third dimension, *perceptions of behavioural control*, represents the person's perception of the level of control he/she has about enacting the behaviour. The latter perceptions can refer to external factors (e.g., availability of resources or time) or internal factors (e.g., perceived capability of enacting the behaviour, which is frequently defined as 'self-efficacy' based on Bandura's concept) (Armitage & Conner, 2001).

These three dimensions consist of subcomponents (i.e., attitudinal factors) that are specific for each attitude-object. A person's views with regard to each of these subcomponents may impact that person's *intention* to (not) enact a specific behaviour (Ajzen, 1991; Ajzen & Fishbein, 1980). It is assumed that the stronger an intention, the more likely it is that the person will enact the behaviour. In this context, this implies that the evaluation of the underlying attitudinal factors that constitute primary school teachers' attitudes towards stimulating higher-order thinking in students determines a teachers' intention to engage in teaching activities that are aimed at stimulating higher-order thinking in students.

## 2.2. Higher-order thinking

Definitions of higher-order thinking vary greatly. Cuban (1984, in Lewis & Smith, 1993) even referred to defining higher-order thinking as a 'conceptual swamp'. Labels such as critical thinking, problem solving, creative thinking, reasoning, metacognition, and reflective thinking are all used to refer to 'higher-order thinking'. Furthermore, perspectives on what higher-order thinking is may differ between disciplines. For example, philosophers generally view thinking as a means to decide what to do or to believe, whereas psychologists are more interested in the process of thinking and how this process can help people make sense of their experiences and surroundings by constructing meaning and imposing structure (Lewis & Smith, 1993; Ten Dam & Volman, 2004).

One of the best-known models addressing higher-order thinking is Bloom's cognitive taxonomy, first published in 1956. In this taxonomy, Bloom and his fellow authors described thinking skills as cognitive processes ranging from relatively simple to more complex. In 2001, Anderson and Krathwohl published a revision of Bloom's taxonomy in which the thinking skills of remembering, understanding, and applying were regarded lower-order thinking skills and analysing, evaluating, and creating were regarded higher-order thinking skills (Anderson et al., 2001).

Another description of higher-order thinking skills is provided by King et al., (1998) who define higher-order thinking as a set of skills that:

> "… include critical, logical, reflective, metacognitive, and creative thinking. These skills are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful application of the skills results in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continued growth in these and other intellectual skills." (p. 1)



In this study, we combined the definitions of King et al., (1998) and Bloom's revised taxonomy (Anderson et al., 2001) to define *stimulating* higher-order thinking, which is the attitude-object of this study, as follows: stimulating higher-order thinking in students means offering assignments, questions, problems or dilemmas where students need to use complex cognitive skills (such as analysing, evaluating and creating) in order to find a solution or make a decision, prediction, judgement, or product. Although stimulating higher-order thinking requires pedagogical knowledge in the context of HOT (i.e., knowledge about *how* to stimulate higher-order thinking), it also (and perhaps even more importantly), requires that teachers' have a positive *attitude* towards stimulating higher-order thinking, which is the focus of the measurement instrument that was developed in the current study.

## 2.3. Teachers' attitudes towards stimulating higher-order thinking

There is some research in which teachers' attitudes towards stimulating higher-order thinking is explored. Based on that research, we learn that primary teachers tend to see the relevance of stimulating students' higher-order thinking (e.g., AlJaafil, &

Şahin, 2019; Ketelhut et al., 2020; Tornero, 2017). However, not all teachers feel capable to engage students in this type of thinking (e.g., Cheeseman, 2018; Schulz and FitzPatrick, 2016) or they experience a lack of time and/or resources (Cheeseman, 2018; Hamdan & Saud Al-Salouli, 2013). Furthermore, a majority of teachers distinguishes between low- and high-achieving students and believes that low-achieving students are less able to engage in higher-order thinking (e.g., AlJaafil, & Şahin, 2019; Alwadai, 2014; Zohar et al., 2001). Although these studies have provided us with some insight in teachers' attitudes towards stimulating higher-order thinking, thus far studies have not combined different attitudinal factors, nor do we have a validated measurement instrument to assess teachers' attitudes in this context. Therefore, the goal of the present study was to develop and validate such an instrument.

# 3. Development of the SHOT questionnaire

We used Trochim and Donnelly's (2006) framework for construct validity to guide the validation of our questionnaire (see Velayutham et al., 2011 for a detailed description of the application of this framework). This framework (see Figure 1) shows that an instrument has high construct validity if it can establish content, face, convergent, discriminant, concurrent and predictive validity.

## 3.1 Establishing translation validity

### *3.1.1. Content validity*

In a previous literature study (Wijnen et al., 2021), we used the TPB as a guideline to structure the attitudinal factors that were previously studied as pertaining to primary school teachers' attitudes towards stimulating higher-order thinking in students. Based on our review of previous research, we were able to identify four attitudinal factors: perceived relevance, perceived students' ability, self-efficacy, and context-dependency. In the present study, we used these four conceptual factors to develop the SHOT questionnaire.

*3.1.1.1. Subscales and items.* To our knowledge, no instrument yet exists that can be used to measure primary school teachers' attitudes towards stimulating higher-order thinking in students. However, there are some questionnaires that are used to measure teachers' attitudes in other contexts. We explored some of these questionnaires to determine whether they can be used as a basis for the development of the SHOT questionnaire. Van Aalderen-Smeets and Walma van der Molen (2013) developed the DAS-instrument to measure primary school teachers' attitudes towards (teaching) *science*. Three conceptual factors (perceived relevance, self-efficacy, and context-

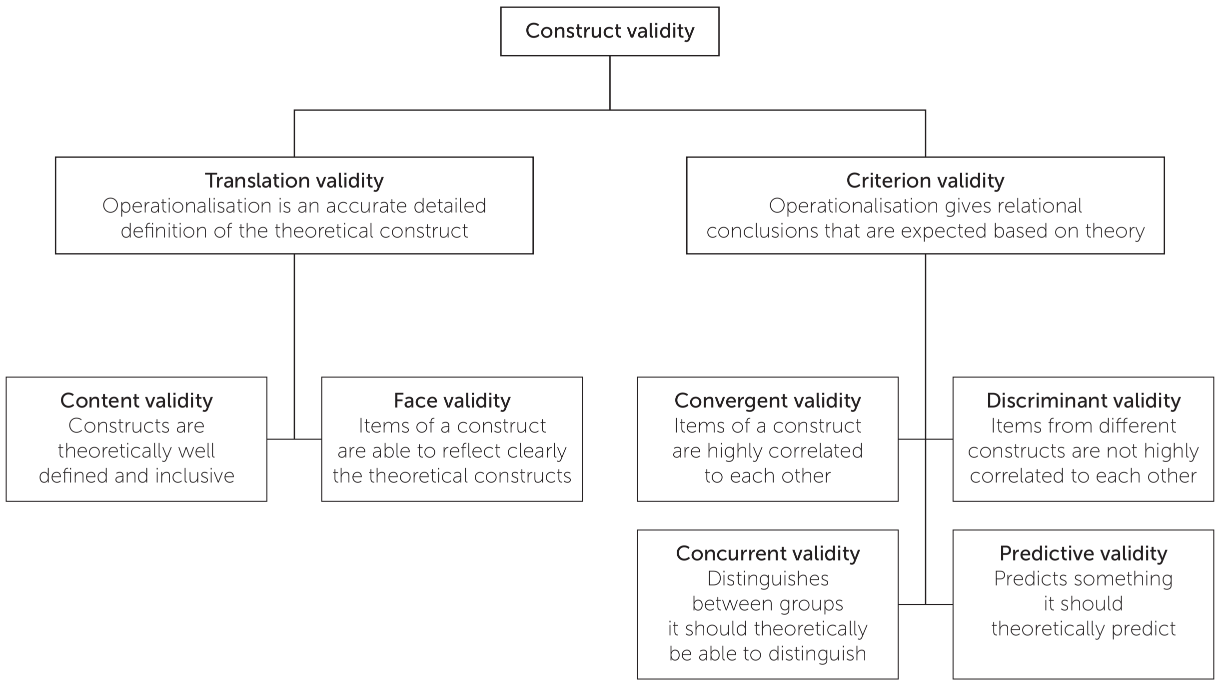


**Figure 1:** Trochim and Donnelly's (2006) framework for construct validity.

dependency) that were developed for the SHOT questionnaire are also included in the DAS questionnaire and the wording of items used to measure these subcomponents seems appropriate. Furthermore, the validity and reliability of the DAS questionnaire has been thoroughly explored (Van Aalderen-Smeets & Walma van der Molen, 2013). We therefore used the DAS-questionnaire as a basis for the development of items for the perceived relevance, self-efficacy, and context-dependency scales in the SHOT questionnaire.

Furthermore, Zohar and Schwartzer (2005) developed a scale to measure teachers' beliefs about teaching higher-order thinking to low-achieving students. We evaluated the items used by Zohar and Schwartzer to determine whether these items might be suitable for measuring the conceptual factor perceived student ability. However, we regarded the reliability (Cronbach's a = 0.59) of that used instrument too low and therefore decided to develop new items for this scale. For the development of new survey items, we considered several important criteria, such as item wording, sequence and format (Schwarz, 2008).

Perceived relevance. Perceived relevance (PR) refers to teachers' beliefs about the importance of stimulating higher-order thinking for students' personal development. We adjusted the items used to measure the scale 'perceived relevance' from the DAS-instrument (Cronbach's a = 0.85) for measuring PR in this study. A resulting item is: 'I think it is essential for the development of students to stimulate higher-order thinking'. We designed four items for this scale.

Perceived student ability. Perceived student ability (PSA) refers to teachers' beliefs about whether higher-order thinking is suitable for both low- and high-achieving students. The items to measure this scale were all newly developed. An example item is: 'I think that most assignments that require higher-order thinking are frustrating for 'weak' students. We designed six items for this scale.

Self-efficacy. Self-efficacy (SE) refers to teachers' self-perceived capability to stimulate higher-order thinking in students. We adjusted the items to measure the scale 'self-efficacy' (Cronbach's a = 0.90) from the DAS-instrument for measuring SE in this study. A resulting item is: 'I am well able to pose questions to my students that stimulate higher-order thinking'. We designed four items for this scale.

Context-dependency. Context-dependency (CD) refers to teachers' perception that external factors, such as available time, or support are a *prerequisite* for them to be able to stimulate higher-order thinking in students. We adjusted the items to measure the scale 'context-dependency' (Cronbach's a = 0.74) from the DAS-instrument for measuring CD in this study. We adjusted these items in order to fit the context of this study and to include external factors that are described as potential obstacles for teachers to stimulate higher-order thinking in students, such as time (e.g., Hamdan & Saoud al-Salouli, 2015) and teacher training (Al-Nouh, Abdul-Kareem, Taqi, 2014). A resulting item is: 'For me, extra time is decisive whether I will stimulate higher-order thinking in my students'. We designed six items for this scale.

Teaching behaviour. In order to determine whether teachers' attitudes towards stimulating higher-order thinking in students, impact teachers' actual teaching behaviour, we added a separate section to measure teachers' self-reported teaching behaviour related to stimulating higher-order thinking in students. This section was used as an outcome measure of the four factors measured with the SHOT questionnaire and contained eight items, such as: 'How often do you design a lesson that explicitly stimulates higher-order thinking in students?' Responses were given on a 7-point Likert scale: (1) never, (2) a few times a year, (3) once a month, (4) a few times a month, (5) once a week, (6) several times a week, (7) every day (see table 1).

*3.1.1.2. Likert-scale.* We chose to develop a Likert-scale instrument. Likert-scale instruments are suitable when items are organized in multiple subscales, they can easily be distributed among a large group of respondents, the questions are easy to answer, and Likert-scales enable parametric testing.

For the attitudinal scales of the SHOT questionnaire, we used a 5-point Likert-scale ranging from strongly disagree to strongly agree. Because it is not always clear how respondents interpret the midpoint of an uneven scale, some argue to only use an even number of response options (Kalton et al., 1980). However, using an even number of response options forces respondents to make a choice, which may lead to skewed results. Therefore, we used a 5-point Likert-scale, where we did not label the middle response options, but only the two extremes (strongly agree-strongly disagree) thereby presenting the response options as a gliding scale.

## 3.2. Face validity

In extensive interviews, five primary school teachers evaluated the first version of the SHOT questionnaire (25 items). These teachers evaluated every item on comprehensibility and clarity. Furthermore, they indicated whether they thought the items were appropriate for measuring the underlying constructs and were asked whether any additional items were necessary. Based on these evaluations several changes were made. These changes included the addition of one more item to the scale PSA, which more explicitly addresses the belief that assignments that require students to engage in higher-order thinking are too difficult for 'weak' students, and the addition of two items to the CD subscale. These items represent two other external factors that teachers might perceive as prerequisites for stimulating higher-order thinking: availability of teacher training, and size of the group of students.

# 4. Investigating criterion validity

## 4.1. Respondents

In order to meet the requirements for criterion validity, the questionnaire (28 items) was distributed among a large group of pre- and in-service primary school teachers (N = 659) in the Netherlands. This group consisted of 257 in-service primary school teachers and 402 third- and fourth-year pre-service teachers. The respondents were mostly females (79,4%), with a mean age of 30 years (range 18-65, *SD* = 12.69).

## 4.2. Procedure

The first author visited the primary schools (for in-service teachers) and the teacher education colleges (for pre-service teachers). After a short introduction and obtaining informed consent, respondents were directed to an online version of the questionnaire (84,2%), which they could fill in using their own devices, such as a smartphone, tablet or laptop or were given a paper-and-pencil version (15,8%). It took respondents approximately 10 minutes to complete the questionnaire. If a respondent did not understand a specific item, the researcher would provide clarification individually. When everyone completed the questionnaire, respondents got the opportunity to ask questions about the questionnaire and research.

In a few cases, it was not possible to agree on a specific time and date for the researcher to visit the school. Therefore, a small number of respondents (approximately 7,5% of the sample) received a link by email redirecting them to the online version of the questionnaire, which they completed on their own.

## 4.3. Data analysis

For our analyses regarding the construct validity and reliability of the SHOT questionnaire, we used similar steps as Post and Walma van der Molen (2019). We started our data analysis by checking the amount of missing data and calculated the standard deviation of respondents' scores on each item. Then, we used a random sampling procedure to extract two subsamples from the dataset, resulting in subsample A (n = 327) and subsample B (n = 332). In order to determine whether the subsamples were equivalent regarding the distribution of pre- and in-service teachers and regarding the sex of the respondents, Chi-square test were used. Results indicated that pre- and in-service teachers ($\chi^2$ = .426, $p$ = .514) and males and females ($\chi^2$ = .505, $p$ = .477) were equally distributed across both subsamples. To explore discriminant and convergent validity, we used subsample A to conduct an exploratory factor analysis (EFA), with Maximum Likelihood estimation (ML) and, since we expected the subscales to correlate, Geomin oblique rotation was used (Field, 2009). This approach helped us identify latent factors underlying teachers' attitudes towards stimulating higher-order thinking in students. As a next step, we used subsample B to conduct a confirmatory factor analysis (CFA) with ML estimation. Unlike EFA, CFA allows for testing model fit, that is, how well the observed data fit a pre-defined hypothesized factor structure.

In addition to the factor analyses, we calculated the Average Variance Extracted (AVE), Maximum Shared Variance (MSV), Average Shared Variance (ASV) and Composite Reliability (CR) to further explore the convergent and discriminant validity of the subscales (Carter, 2016; Raykov, 1997). Discriminant validity is satisfactory when AVE is equal or greater than 0.50 and greater than the ASV and MSV of its factor. For convergent validity, the CR value should be equal or greater than 0.70 and be greater than the AVE of the subscale (Fornell & Larcker, 1981). Furthermore, we explored factor correlations. Results of these additional analyses are reported in Appendix A. For the analyses, we used the MPlus program (Muthén & Muthén, 1998-2015).

# 5. Results



## 5.1. Preliminary data checks

We started our data analysis by checking for missing data. In the online version of the questionnaire, we used a 'forced response' option. Therefore, respondents had to answer all items before being able to complete the questionnaire. This was not possible for the paper-and-pencil version of the questionnaire, but there were only a few respondents who did not answer one or more items. The percentage of missing data was 0.2% for subsample A and 0.4% for subsample B. We used the default option for handling missing data in MPlus.

Next, for each item, we calculated the standard deviation and checked whether each response option was used at least once. For a five-point Likert-scale, the standard deviation should approximate 1.0 (Coulson, 1992). For the 5-point Likert scale standard deviations ranged from .839 to 1.089. For the 7-point Likert scale (teaching behaviour) standard deviations ranged from 1.387 to 1.873. All response options were used at least once. We concluded that the data were suitable for conducting factor analyses.

## 5.2. Exploratory factor analysis

We conducted iterative exploratory factor analyses with subsample A. Items with a factor loading below 0.35 or cross loadings less than 0.15 from an item's greatest factor loading (Worthington & Whittaker, 2006) were deleted from further EFA's.

Two items designed to measure context-dependency were deleted due to cross-loadings. The resulting EFA revealed a four-factor structure, as was anticipated (see Table 1). The four factors are: Perceived relevance (eigenvalue 5.487), perceived student ability (eigenvalue 4.404), self-efficacy (eigenvalue 1.915), and context-dependency (eigenvalue 1.169).

## 5.3. Confirmatory factor analysis

To explore how well the data from subsample B fitted the four-factor structure that we had identified with EFA, we performed a CFA. We used several goodness-of-fit indices to determine model fit. These indices are Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). SRMR $\geq$.0.08 indicates good fit (Prudon, 2015), CFI and TLI $\geq$ 90 indicate acceptable fit and $\geq$.95 indicate good fit (Brown, 2006). RMSEA values $\geq$.0.08 indicate adequate fit, and $\geq$.0.05 indicate good fit (Brown, 2006). Since the $\chi^2$ has some shortcomings (see Hooper et al., 2008; Prudon, 2015) we only report the $\chi^2$ for completeness. The above thresholds are used as guidelines and not interpreted as strict rules (Prudon, 2015).

Results of the CFA for the SHOT questionnaire showed acceptable to good fit, SRMR = 0.067, RMSEA = 0.079, $\chi^2$ = 389.203, *df* = 129, *p* < 0.001, CFI = 0.929, TLI = 0.916. Table 1 presents the resulting factor structure of the SHOT questionnaire. As explained above, we calculated CR, AVE, ASV and MSV for each subscale as obtained by CFA as an additional check of convergent and discriminant validity. The results of these analyses indicated sufficient convergent and discriminant validity and are reported in Appendix A. Furthermore, we calculated the factor correlations to explore the relationships between the four attitudinal factors. The correlation matrix can also be found in Appendix A.

## 5.4. Teaching Behaviour

We analysed the teaching behaviour scale separately from the attitudinal factors. Before conducting our analyses, we first evaluated the items of the teaching behaviour scale to develop some hypotheses regarding the factor structure. Based on these evaluations we hypothesized that either a one-factor or two-factor structure might be appropriate. A one-factor structure might be appropriate because all items aim to measure the frequency of teachers' behaviour aimed at stimulating higher-order thinking. A two-factor structure might be appropriate because some items are focused on different activities a teacher can undertake to stimulate higher-order thinking (e.g., design a lesson, teach a lesson, give assignments), whereas other items are more focused on encouraging students to engage in different complex thinking processes (e.g., problem solving, creating new products). We therefore analysed both a one-factor and two-factor structure. Since the two-factor structure yielded better results, we will only report the results of the two-factor structure.

We conducted iterative EFA's using subsample A. Three items were deleted due to cross-loadings. Results of the EFA with a two-factor structure showed that three items related to teacher activities (TA) loaded highly together on one factor (eigenvalue 3.523) and two items related to encouraging students (ES) loaded highly together on another factor (eigenvalue 0.920) (see Table 2).

Next, we conducted a CFA using subsample B to further explore the two-factor structure. Results of the CFA are: $\chi^2 = 31.186$, $df = 4$, $p = <0.001$, RMSEA = 0.144, SRMR = 0.028, CFI = 0.977, TLI = 0.942. These results are confusing because CFI and SRMR indicate very good fit, TLI indicates reasonable fit, but RMSEA indicates very poor fit. A possible explanation for these findings could be that this model has small degrees of freedom ($df = 4$) and a relatively small sample size (n = 327) was used. According to Kenny, Kaniskan, and McCoach (2015) RMSEA can falsely indicate poor fit in models with small degrees of freedom. This effect is stronger when small sample sizes are used. Shi, DiStefano, Maydeu-Olivares and Lee (2021) recommend relying on SRMR and CFI in such situations. Since the SRMR and CFI indicate very good fit, we conclude that the two-factor structure is appropriate. The resulting factor loadings are reported in Table 2.



The factor encouraging students (ES) consists of two items. It is preferable that a factor is represented by at least three items. However, a factor with two items can be used when the items are strongly correlated with each other (Eisinga et al., 2013) using the Spearman-Brown correlation. The two items for measuring ES were strongly correlated with each other, $\rho = 0.88$. Therefore, we decided to keep this factor. For teaching behaviour, we also calculated the CR, AVE, ASV and MSV for each subscale as obtained by CFA. The results of these analyses also indicated sufficient convergent and discriminant validity. Furthermore, we again calculated the factor correlations. The results of these analyses are also reported in Appendix A.

## 5.5. Predictive validity

We performed regression analyses (using all data) to investigate whether scores on the attitude subscales have predicative value for teachers' (self-reported) teaching behaviour, measured by the scales teacher activities (TA) and encouraging students (ES).

Results of the regression analyses (see Table 3) show that the attitude factors PR, SE and CD are significant predictors for TA. Furthermore, the attitude factors PR and SE are significant predictors for ES. Interestingly, PSA is not a significant

**Table 1** Factor structure for the SHOT questionnaire

| | | EFA | | | | CFA | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Item | PR | PSA | SE | CD | PR | PSA | SE | CD |
| PR1 | I think it is essential for the learning of students that they are encouraged to engage in higher-order thinking | 0.780 | | | | 0.892 | | | |
| PR2 | In order to stimulate students' development, I think that you cannot start early enough with offering assignments in which higher-order thinking comes into play | 0.714 | | | | 0.833 | | | |
| PR3 | I think it is essential for the development of students to stimulate higher-order thinking | 0.878 | | | | 0.882 | | | |
| PR4 | I think that stimulating higher-order thinking is so important, that all teachers should do this regularly in their lessons | 0.896 | | | | 0.850 | | | |
| PSA1 | I think that 'smart' students are much better at higher-order thinking than 'weak' students | | 0.717 | | | | 0.676 | | |
| PSA2 | I think that 'weak' students cannot handle assignments that require higher-order thinking | | 0.726 | | | | 0.802 | | |
| PSA3 | I think that most assignments that require higher-order thinking are too difficult for 'weak' students | | 0.864 | | | | 0.824 | | |
| PSA4 | I think that most assignments that require higher-order thinking are frustrating for 'weak' students | | 0.637 | | | | 0.824 | | |
| PSA5 | I think that assignments that require higher-order thinking are more appropriate for 'smart' students than for 'weak' students | | 0.751 | | | | 0.802 | | |
| PSA6 | I think that we cannot expect much higher-order thinking from 'weak' students | | 0.727 | | | | 0.781 | | |
| SE1 | I am well able to pose questions to my students that stimulate higher-order thinking | | | 0.650 | | | | 0.806 | |
| SE2 | I have enough skills to enrich my lessons with higher-order thinking assignments | | | 0.764 | | | | 0.818 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SE3 | I am well able to guide students in doing assignments that stimulate them to engage in higher-order thinking | | | 0.649 | | | | 0.876 | |
| SE4 | I am well able to make-up assignments that stimulate my students to engage in higher-order thinking | | | 0.890 | | | | 0.820 | |
| CD1 | For me, extra time is decisive whether I will stimulate higher-order thinking in my students | | | | 0.548 | | | | 0.623 |
| CD2 | For me, making higher-order thinking assignments is only possible when I have a method that describes how to do that | | | | 0.633 | | | | 0.708 |
| CD3 | For me, a custom package with sample materials (for example Denksleutels) is conditional for stimulating higher-order thinking in my students | | | | 0.652 | | | | 0.736 |
| CD4 | For me, the size of the group determines whether I will stimulate higher-order thinking in my students | | | | 0.642 | | | | 0.493 |

Notes:

a. Exploratory Factor Analysis (EFA) conducted with Maximum Likelihood (ML) estimation and Geomin rotation with subsample A, $N$ = 327. Values represent factor loadings.

b. Confirmatory Factor Analysis (CFA) conducted with Maximum Likelihood (ML) estimation and Geomin rotation with subsample B, $N$ = 332. Values represent factor loadings.

c. Factor loadings are only displayed for >.35

d. PR = Perceived Relevance, PSA = Perceived Student Ability, SE = Self-efficacy, CD = Context-dependency,

e. The items were originally developed in Dutch. This table presents the English translations.

**Table 2** Factor structure for the teaching behaviour scales

| | Item | EFA | | CFA | |
|---|---|---|---|---|---|
| | | TA | ES | TA | ES |
| TA1 | How often do you design a lesson that explicitly stimulates higher-order thinking in students? | 0.927 | | 0.836 | |
| TA2 | How often do you teach a lesson (self-designed or based on a teaching method) that explicitly stimulates higher-order thinking in students? | 0.934 | | 0.921 | |
| TA3 | How often do you give assignments to your students that require higher-order thinking? | 0.720 | | 0.888 | |
| ES1 | How often do you encourage your students to find more than one solution for a problem? | | 0.952 | | 0.929 |
| ES2 | How often do you encourage your students to approach a subject from different perspectives (such as suggesting pro and counterarguments)? | | 0.777 | | 0.851 |

Notes:
a. Exploratory Factor Analysis (EFA) conducted with Maximum Likelihood (ML) estimation and Geomin rotation with subsample A, $N$ = 327. Values represent factor loadings.
b. Confirmatory Factor Analysis (CFA) conducted with Maximum Likelihood (ML) estimation and Geomin rotation with subsample B, $N$ = 332. Values represent factor loadings.
c. Factor loadings are only displayed for >.35
d. TA = Teaching Activities, ES = Encouraging Students
e. The items were originally developed in Dutch. This table presents the English translations.

predictor for TA or ES, indicating that teachers' beliefs about the capability of students to engage in higher-order thinking does not significantly impact their teaching behaviour. In addition, only PR and SE explain a reasonable amount of variance in TA and in ES, indicating that these factors have a stronger influence on teachers' teaching behaviour.

## 5.6. Concurrent validity

In order to evaluate concurrent validity of the SHOT questionnaire, we need to know whether we can expect differences in attitudes between different groups of respondents, based on theory (Trochim & Donnely, 2006). If such differences exist, one should be able to distinguish between these groups based on the scores of the respondents on the questionnaire.

**Table 3** Regression analyses per variable (*N* = 659)

| | *B* | *SD* | *t* | *p* | $R^2$ |
|---|---|---|---|---|---|
| **Teacher activities** | | | | | |
| Perceived relevance | 0.418 | 0.036 | 11.709 | <0.001 | 0.175* |
| Perceived student ability | -0.042 | 0.043 | -0.976 | 0.329 | 0.002 |
| Self-efficacy | 0.608 | 0.029 | 21.126 | <0.001 | 0.369* |
| Context dependency | -0.218 | 0.046 | -4.790 | <0.001 | 0.048* |
| **Encouraging students** | | | | | |
| Perceived relevance | 0.577 | 0.030 | 19.134 | <0.001 | 0.333* |
| Perceived student ability | 0.071 | 0.043 | 1.623 | 0.103 | 0.005 |
| Self-efficacy | 0.482 | 0.038 | 12.573 | <0.001 | 0.305* |
| Context dependency | 0.038 | 0.048 | 0.781 | 0.435 | 0.001 |

*Significant at $\alpha < 0.05$

In our study, we include two groups of teachers: pre-service teachers and in-service teachers. This indicates that if previous work shows that pre- and in-service teachers have different attitudes towards stimulating higher-order thinking in students, we should be able to distinguish between pre- and in-service teachers based on their scores on the SHOT questionnaire.

However, to our knowledge no previous work exists in which pre- and in-service teachers' attitudes towards stimulating higher-order thinking in students are compared in order to evaluate whether they differ in their attitudes. Due to this lack of a theoretical basis, it is not possible to evaluate the concurrent validity of the SHOT questionnaire. However, we will evaluate whether pre- and in-service teachers' scores on the SHOT questionnaire differ significantly from each other. In order to do that, we first need to establish measurement invariance to ensure that the scores of the participants may be compared (i.e., whether both groups interpret the items similarly). We therefore evaluate whether the factor structure, factor loadings and factor intercepts are similar for both groups of respondents.

### *5.6.1 Measurement invariance*

Detailed analyses of measurement invariance are reported in Appendix B. Results of these analyses showed that configural invariance (i.e., similarity of the factor structures) and metric invariance (i.e., similarity of factor loadings) could be established. However scalar invariance (i.e., similarity of factor intercepts) could not be established for item PSA1 ("I think that 'smart' students are much better at higher-order thinking than 'weak' students"). Marsh and Hocevar (1985) suggest that if the noninvariant items constitute only a small portion of the model, group comparisons may still be made, because the noninvariant items are not expected to affect the comparisons in a meaningful degree. We therefore decided to keep this item.

#### *5.6.1.2. Teaching behaviour*

Results of the measurement invariance analyses for the teaching behaviour scales indicated that configural and metric invariance could be established. However, scalar invariance could not be established for item TA1 ("How often do you design a lesson that explicitly stimulates higher-order thinking in students?"). Since omission of item TA1 would result in very few items for measuring teaching behaviour, we decided to keep this item. However, we conclude that caution should be used when comparing pre- and -in-service teachers' scores for the teacher activities scale.

### *5.6.2. Primary school teachers' attitudes towards stimulating higher-order thinking*

Although the primary goal of this study was to develop and validate the SHOT questionnaire, the data also provide us with the opportunity to explore potential differences in pre- and in-service teachers' scores. To that end, we calculated the unweighted average scores of pre- and in-service primary teachers on the four attitudinal factors. Table 4 provides an overview of these scores.

The results indicate that pre- and in-service teachers believe stimulating higher-order thinking is relevant to support students in their development, believe that higher-order thinking is appropriate for low-achieving students, feel moderately capable in stimulating higher order thinking, and feel moderately dependent on context-factors.

To explore whether pre- and in-service teachers differ significantly in their attitudes, we performed a MANOVA with 'teacher type' as the between-subject factor, using SPSS version 24. As dependent variables we used the unweighted average scores, which represents the mean score for each participant for every attitudinal factor.

Results of the MANOVA resulted in a significant effect of 'teacher type', Wilks' Lamba $\Lambda = .811$, $F(4, 654) = 38.110$, $p = <0.001$, $\eta 2 = 0.189$. To determine on which factors pre- and in-service teachers score significantly different, we performed several post-hoc univariate analyses. Because we performed multiple ANOVA's, we used a Bonferroni correction to prevent incorrectly rejecting the null hypothesis (Type 1 error). This means that the *p*-value should be below 0.0125 to be significant. The results showed that (1) in-service teachers perceive stimulating higher-order thinking as more relevant and (2) in-service teachers perceive themselves significantly more capable to stimulate higher-order thinking in students (see Table 5).

**Table 4** Unweighted average scores for each attitudinal component

| | pre- and in-service teachers (*N* = 659) | | in-service teachers (*N* = 257) | | pre-service teachers (*N* = 402) | |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| Perceived relevance | 3.58 | 0.961 | 4.06 | 0.669 | 3.28 | 0.995 |
| Perceived student ability* | 2.28 | 0.737 | 2.36 | 0.772 | 2.22 | 0.708 |
| Self-efficacy | 3.04 | 0.813 | 3.21 | 0.692 | 2.92 | 0.864 |
| Context-dependency | 2.54 | 0.740 | 2.60 | 0.782 | 2.50 | 0.711 |

* a lower score indicates that the teacher believes HOT is suitable for low-achieving students

**Table 5** Univariate post-hoc analyses

| | pre-service vs in-service teachers | |
|---|---|---|
| | η2 | *p* |
| Perceived relevance | 0.159 | **<0.001** |
| Perceived student ability | 0.009 | 0.017 |
| Self-efficacy | 0.030 | **<0.001** |
| Context-dependency | 0.004 | 0.102 |

Note: *N* = 402 for pre-service teachers, *N* = 257 for in-service teachers

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### *5.6.3. Teaching behaviour*

On average, both pre- and in-service teachers engage in teaching activities aimed at stimulating higher-order thinking a bit more often than a few times a year (*M* = 2.87, *SD* = 1.359). Furthermore, they encourage students in higher-order thinking more often than once a month (*M* = 3.88 *SD* = 1.728). Table 6 gives an overview of how often teachers engage in teaching activities and how often they encourage students to engage in higher-order thinking.

In order to explore whether pre- and in-service teachers differ significantly in how often they stimulate higher-order thinking in students, we performed a MANOVA with 'teacher type' as the between-subjects variable. Results of the MANOVA resulted in a significant effect of 'teacher type', Wilks' Lamba Λ = .908, $F(2, 650) = 32.881$, $p$ = <0.001, η2 = 0.092. In order to determine on what factor pre- and in-service teachers score significantly different, we performed a post-hoc univariate analysis. Results showed that in-service teachers encourage students significantly more

**Table 6** Frequency of stimulating higher-order thinking

| | pre- and in-service teachers (*N* = 659) | | in-service teachers (*N* = 257) | | pre-service teachers (*N* = 402) | |
|---|---|---|---|---|---|---|
| | *N* | *%* | *N* | *%* | *N* | *%* |
| ***Mean score TA*** | | | | | | |
| 1.00-1.99 | 112 | 17.0 | 70 | 27.2 | 42 | 10.5 |
| 2.00-2.99 | 250 | 38.0 | 81 | 31.4 | 169 | 42.1 |
| 3.00-3.99 | 122 | 18.6 | 40 | 15.6 | 82 | 20.3 |
| 4.00-4.99 | 101 | 15.3 | 40 | 15.6 | 61 | 15.2 |
| 5.00-5.99 | 45 | 6.8 | 13 | 5.1 | 32 | 7.9 |
| 6.00-7.00 | 24 | 3.6 | 11 | 4.3 | 13 | 3.2 |
| Missing | 5 | 0.8 | 2 | 0.8 | 3 | 0.7 |
| ***Mean score ES*** | | | | | | |
| 1.00-1.99 | 43 | 6.6 | 17 | 6.7 | 26 | 6.5 |
| 2.00-2.99 | 168 | 25.5 | 37 | 14.4 | 131 | 32.6 |
| 3.00-3.99 | 98 | 14.9 | 37 | 14.4 | 61 | 15.2 |
| 4.00-4.99 | 117 | 17.7 | 49 | 19.1 | 68 | 16.9 |
| 5.00-5.99 | 98 | 14.9 | 52 | 20.2 | 46 | 11.4 |
| 6.00-7.00 | 129 | 19.6 | 62 | 24.1 | 67 | 16.7 |
| Missing | 6 | 0.9 | 3 | 1.2 | 3 | 0.7 |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Teaching Activities | 2.87 | 1.359 | 2.74 | 1.414 | 2.95 | 1.319 |
| Encouraging students | 3.88 | 1.728 | 4.29 | 1.695 | 3.61 | 1.700 |

Note: 1 = never, 2 = a few times a year, 3 = once a month, 4 = a few times a month, 5 = once a week, 6 = a few times a week, and 7 = every day.

often to engage in higher-order thinking than pre-service teachers (F(1, 651) = 24.642, *p* = <0.001, η2 = 0.36). There was no significant difference between pre- and-in-service teachers for how often they engage in teaching activities (*p* = 0.055, η2 = 0.006).

## 6. Discussion

The goal of this study was to develop and establish the validity and internal consistency of the SHOT questionnaire. In an earlier conducted literature review (Wijnen et al., 2021), we used the TPB to extract four attitudinal factors that we aim to measure with the SHOT questionnaire. Results of our analyses showed that the construct validity for these four attitudinal factors could be supported.

Using the TPB to explore factors that may influence teachers' behaviour aimed at stimulating children's thinking is not entirely new. In a previous study, Lee (2018) used the TPB and Social Cognitive Theory from Bandura, to gain insight into what educators should do to help students become critical thinkers. Lee (2018) found, among other things, that positive (student) attitudes should be promoted by recognizing the positive consequences of critical thinking. Lee (2018) proposed to implement instructional strategies, such as role playing, student-initiated storytelling and problem-based learning. However, although the study by Lee provides suggestions for what teachers can do to stimulate critical thinking in students, it provides little insight into what factors account for teachers' *attitudes* towards stimulating higher-order thinking. After all, according to the TPB, a positive attitude towards stimulating higher-order thinking predicts teachers' intention to act accordingly. Therefore, we argue that insight in teachers' attitudes is important in training and coaching teachers in using the kind of instructional strategies Lee proposes. Furthermore, the SHOT questionnaire can be used to investigate, monitor and evaluate the effects of teacher training programs aimed at developing more positive teacher attitudes.

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In the present study, we wished to explore whether we were able to measure the four attitudinal factors (PR, PSA, SE, and CD) that we identified in our earlier conducted literature review. However, in that literature review we found that the amount of work on teachers' attitudes towards stimulating higher-order thinking was limited. It is therefore possible that other attitudinal factors might also be relevant when exploring teachers' attitudes towards stimulating higher-order thinking in students. Based on the TPB (Ajzen, 1991; 2001), we expect that such factors might include affective components (e.g., anxiety or enjoyment), teachers' views of the social norm regarding stimulating higher-order thinking (does a teacher believe that stimulating higher-order thinking is appreciated by important others, such as colleagues?), and teachers' perceived difficulty (does a teacher believe it is difficult or easy to engage students in higher-order thinking?). Inclusion of additional factors might also help in explaining more of the variance in the TA and ES scales. In the present study, we found that only PR and SE explain a reasonable amount of variance ($R^2$ for TA ranges between 0.175 – 0.369, $R^2$ for ES ranges between 0.305 – 0.333), but there is still variance that could not be explained by the four factors.

We therefore recommend that researchers explore whether inclusion of additional factors to the SHOT questionnaire helps us better understand teachers' behaviour aimed at stimulating higher-order thinking.

As a starting point, we designed several potential items related to the affective component, the perceived social norm component, and the perceived difficulty component, which might be included in the SHOT questionnaire (see Appendix C). Furthermore, the teaching behaviour scale 'encouraging students' presently consists of two items only. It is preferable that a factor consists of at least three items (Eisinga et al., 2013) and we therefore propose another six items that might be used to expand this factor (see Appendix D).

In line with previous work (AlJaafil, & Şahin, 2019; Ketelhut et al., 2020; Tornero, 2017), we found that both pre- and in-service primary teachers think it is important to stimulate higher-order thinking in students. Also, in line with previous work, we found that most teachers do not feel capable to stimulate higher-order thinking. In addition, we found that both pre- and in-service teachers mostly agree that higher-order thinking is also suitable for low-achieving students. The latter finding is in contrast with previous work, which shows that most teachers believe that low-achieving students are unable to engage in higher-order thinking (e.g., Zohar et al., 2001). There could be a number of reasons for the differing results, such as differences in item wording or the fact that we did not measure how our respondents define 'smart' and 'weak' students. Further research, such as in-depth interviews might shed more light on this issue.

We found that the factors PR, SE, and CD have a significant impact on teaching behaviour. This is valuable because, although teachers' perceptions regarding the relevance of stimulating higher-order thinking, teachers' perceived ability to do this and teachers' perceived dependency on context-factors to stimulate higher-order thinking were explored in previous studies (e.g., Akinoglu & Karsantik, 2016; Baysal et al., 2010; AlJaafil, & Şahin, 2019; Cheeseman, 2018; Ketelhut et al., 2020), none of these studies investigated to what extent these factors impact actual teaching behaviour aimed at stimulating higher-order thinking.

Based on the TPB, we expected that a more positive attitude towards stimulating higher-order thinking would result in a higher frequency of teaching behaviour. In this study, we found that both pre- and in-service teachers are somewhat positive about stimulating higher-order thinking. Furthermore, we found, in line with the TPB, that in-service teachers, who are more positive about the relevance of stimulating higher-order thinking and their perceived ability to do this, encourage students significantly more often to engage in higher-order thinking than pre-service teachers do, but still not very often (approximately a few times a month).

One could argue that pre- and in-service teachers differ in the amount of overall teaching that they engage in. Unfortunately, we did not collect data on how much time the participating pre- and in-service teachers spent on teaching. However, we do know that in the Netherlands approximately 55% of in-service teachers work parttime (15 % works less than 2,5 days and 40% works 2,5 – 4 days a week; OCW, 2020). On the other hand, third- and fourth-year pre-service teachers teach at least one day a week with a maximum of 3 days a week. We therefore expect no large differences in teaching time that could account for the finding that in-service teachers stimulate higher-order thinking more often than pre-service teachers.

To conclude, the results of the current study show that the requirements for construct validity of the SHOT questionnaire could all be met. Although we carefully translated the items from Dutch to English for this article, cross-cultural validation should determine the construct validity of the SHOT questionnaire in different countries. In addition, we encourage researchers to extent the SHOT questionnaire with the additional factors that we suggested.

As a next step, we intend to explore whether the SHOT questionnaire can be used to identify different groups of teachers, based on their attitudes towards stimulating higher-order thinking in students. Identifying such groups would allow us to develop teacher training programs to support different groups of teachers in stimulating higher-order thinking in students.

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# Appendix A: CR, AVE, MSV, ASV and factor correlations, for the SHOT-questionnaire

## A.1. CR, AVE, MSV, and ASV for the attitudinal factors

We calculated CR, AVE, ASV, and MSV for each attitudinal subscale as obtained by CFA. The composite reliability scores indicated good internal consistency of the subscales. Scores for all factors were above the threshold of .70 and exceeding the AVE scores of each respective subscale. Furthermore, AVE scores indicated good discriminant power of the subscales, since all were ≥ 0.5 and exceeded the ASV and MSV scores for each respective subscale (see Table A.1).

## A.2. CR, AVE, MSV, and ASV for the teaching behaviour scales

We calculated the AVE and CR score and explored the shared variance of the TA and ES scales. For both scales the AVE and CR scores were above the thresholds of 0.5 and 0.7 respectively (see Table A.1.), indicating good discriminating power and internal consistency of the subscales.

## A.3. Factor correlations

We calculated the correlations to gain insight in the relationships between the four attitudinal factors. The correlation matrix (Table A.1.) shows that there is a significant positive correlation between perceived relevance and self-efficacy. It is possible that teachers who consider it important to stimulate higher-order thinking in students are more inclined to do this and because they have more experience have more positive views regarding their competency to engage students in higher-order thinking processes.

Furthermore, there is a significant positive correlation between perceived student ability and context-dependency. A higher score on perceived student ability indicates that teachers believe that higher-order thinking is not suitable for 'weak' students. This significant correlation might indicate that teachers who are unsure about whether higher-order thinking is suitable for 'weak' students, feel that they need additional support in order to be well able to engage students in higher-order thinking.

In addition, all four attitudinal factors (PR, PSA, SE, and CD) are significantly correlated with the behavioural scale TA. This might indicate that these factors impact teachers' engagement in teaching activities aimed at stimulating higher-order thinking in students. Also, the factors PR and SE are significantly correlated with the behavioural scale ES. This might indicate that teachers' beliefs about the importance of stimulating higher-order thinking and their perceived ability to do this impact teachers' behaviour to engage students in different higher-order thinking processes.

**Table A.1** CR, AVE, MSV, ASV and factor correlations for the SHOT-questionnaire (*N* =332)

| | Perceived relevance | Perceived student ability | Self-efficacy | Context-dependency | Teacher Activities | Encouraging students |
|---|---|---|---|---|---|---|
| Perceived relevance | | -0.084 | 0.790* | -0.091 | 0.473* | 0.622* |
| Perceived student ability | | | -0.021 | 0.636* | -0.122* | 0.053 |
| Self-efficacy | | | | -0.092 | 0.579* | 0.542* |
| Context-dependency | | | | | -0.230* | 0.072 |
| Teacher Activities | | | | | | 0.680* |
| Composite Reliability (CR) | 0.90 | 0.81 | 0.90 | 0.73 | 0.91 | 0.88 |
| Average Variance Extracted (AVE) | 0.85 | 0.72 | 0.80 | 0.61 | 0.87 | 0.88 |
| Average Shared Variance (ASV) | 0.21 | 0.14 | 0.21 | 0.14 | 0.46 | 0.46 |
| Maximum Shared Variance (MSV) | 0.62 | 0.40 | 0.62 | 0.40 | 0.46 | 0.46 |

* Factor correlation is significant at $p$ = <0.05

# Appendix B: Detailed analyses of measurement invariance

## B.1. Measurement invariance for the attitudinal factors

In order to establish measurement invariance, we conducted a multiple-group CFA (for a more in-depth explanation of measurement invariance, see Chen, 2007) including the factors PR, PSA, SE and CD. We explored configural invariance (i.e., similarity of the factor structures), metric invariance (i.e., similarity of factor loadings) and scalar invariance (i.e., similarity of factor intercepts) using all data (*N* = 659).
In order to determine invariance, differences in $\chi^2$ (i.e., $\Delta\chi^2$) between the different measurement models (configural, metric, and scalar) are explored. However, because $\chi^2$ is sensitive to sample size and model assumptions (e.g., linearity, multivariate normality) (Byrne, Shavelson, & Muthén, 1989), we only report $\Delta\chi^2$ for completeness. Instead, we use ΔCFI (Cheung & Rensvold, 2002), ΔRMSEA and ΔSRMR (Cheng, 2007).

For establishing metric invariance, a ΔCFI of $\leq$-0.01, a ΔRMSEA of $\leq$0.015 and a ΔSRMR of $\leq$0.03 indicate invariance. For scalar invariance, ΔSRMR should be $\leq$0.01. In order to establish metric invariance, fit indices of the metric model were compared with fit indices of the configural model. In order to establish scalar invariance, fit indices of the scalar model were compared with fit indices of the metric model.

As can be seen from Table B.1, fit indices for the configural model indicate acceptable fit. Furthermore, the Δ-indices for the metric model were below the recommended thresholds, indicating metric invariance. However, ΔCFI for the comparison between the metric and scalar model exceeded the recommended threshold of -0.01 and therefore scalar invariance could not be established.

In order to determine whether scalar invariance could not be established for a specific factor, several measurement invariance analyses were conducted. Results show that there was no invariance for the factor perceived student ability. More specifically, results showed that there was no invariance for the item 'I think that 'smart' students are much better at higher-order thinking than 'weak' students. Excluding this item resulted in scalar invariance. Since, Marsh and Hocevar (1985) suggest that if the noninvariant items constitute only a small portion of the model, then group comparisons may still be made, because the noninvariant items were not expected to affect the comparisons in a meaningful degree, we decided to keep this item.

**Table B.1** Measurement invariance analysis for the attitudinal factors

| | $\chi^2$ | *df* | CFI | RMSEA | SRMR | $\Delta\chi^2$ | *p* | ΔCFI | ΔRMSEA | ΔSRMR |
|---|---|---|---|---|---|---|---|---|---|---|
| Configural model | 776.43 | 258 | 0.93 | 0.078 | 0.069 | - | - | - | - | - |
| Metric model | 812.79 | 272 | 0.93 | 0.078 | 0.078 | 36.36 | <0.001 | -0.00 | 0.000 | 0.009 |
| Scalar model | 953.80 | 286 | 0.91 | 0.084 | 0.085 | 141.01 | <0.001 | -0.02 | 0.006 | 0.007 |
| ***Excluding PSA item 1*** | | | | | | | | | | |
| Configural model | 597.26 | 196 | 0.94 | 0.079 | 0.068 | - | - | - | - | - |
| Metric model | 632.38 | 208 | 0.93 | 0.079 | 0.078 | 35.11 | <0.001 | -0.01 | 0.000 | 0.010 |
| Scalar model | 711.31 | 220 | 0.92 | 0.082 | 0.083 | 78.93 | <0.001 | -0.01 | 0.003 | 0.005 |

Groups compared: pre-service teachers ($N$ = 402) vs. in-service teachers ($N$ = 257).

## B.2. Measurement invariance for the teaching behaviour scales

In order to test measurement invariance for teachers' behaviour aimed at stimulating higher-order thinking, we performed another multiple-group CFA for the TA and ES scales. Results, presented in Table B.2, show that configural invariance could be established. Furthermore, all indices indicate metric invariance, except ΔRMSEA, which is slightly above the threshold of 0.015. Scalar invariance could not be established since both ΔRMSEA and ΔSRMR are above the recommended thresholds.

In order to explore whether scalar invariance could not be established for a specific item, multiple measurement invariance analyses were conducted. Results showed that there was no invariance for item TA1. Since omission of item TA1 would result in very few items for measuring teaching behaviour we decided to keep this item. However, caution should be used when comparing pre- and -in-service teachers' scores for the teacher activities scale.

**Table B.2** Measurement invariance analysis for teaching behaviour

| | $\chi^2$ | *df* | CFI | RMSEA | SRMR | $\Delta\chi^2$ | *p* | ΔCFI | ΔRMSEA | ΔSRMR |
|---|---|---|---|---|---|---|---|---|---|---|
| Configural model | 8.65 | 32 | 1.000 | 0.016 | 0.020 | - | - | - | - | - |
| Metric model | 9.30 | 29 | 1.000 | 0.000 | 0.023 | 0.655 | 0.884 | 0.000 | 0.016 | 0.003 |
| Scalar model | 18.06 | 26 | 0.998 | 0.030 | 0.036 | 8.756 | 0.033 | 0.002 | 0.030 | 0.013 |
| ***Excluding TA1*** | | | | | | | | | | |
| Configural model | 1.62 | 26 | 1.000 | 0.000 | 0.004 | - | - | - | - | - |
| Metric model | 2.05 | 24 | 1.000 | 0.000 | 0.009 | 0.429 | 0.807 | 0.000 | 0.000 | 0.005 |
| Scalar model | 2.16 | 22 | 1.000 | 0.000 | 0.008 | 0.115 | 0.944 | 0.000 | 0.000 | -0.001 |

# Appendix C: Potential additional scales and items to expand the SHOT questionnaire

## Enjoyment

- I feel enthusiastic when stimulating higher-order thinking in my students
- I feel satisfied when I stimulate higher-order thinking in my students.
- I enjoy stimulating higher-order thinking in my students
- I feel pleasure when I see my students engaging in higher-order thinking

## Anxiety

- I get a sinking feeling when I have to design an assignment to engage my students in higher-order thinking
- I feel nervous about creating assignments to engage my students in higher-order thinking
- I feel anxious when I have to guide students through higher-order thinking assignments
- I feel tense when students pose unexpected questions
- I feel stressed about evaluating open ended solutions that my students come up with.



## Social norm

- I think that my colleagues believe it is essential to engage students in higher-order thinking
- I think that my colleagues appreciate it when I design assignments to engage my students in higher-order thinking
- I think that, at our school, stimulating higher-order thinking in students is viewed as important
- I think that, at our school, it is expected of me that I engage my students in higher-order thinking

## Perceived difficulty

- I think it is very difficult to pose questions that stimulate higher-order thinking in my students
- I think it requires a lot of effort to design assignments that stimulate my students to engage in higher-order thinking
- I think it is difficult to coach students when they engage in higher-order thinking

# Appendix D: Potential additional items to expand the ‘Encouraging Students’ scale

## Suggested additional items to the scale Encouraging Students:

- How often do you encourage your students to approach a subject from different perspectives (such as suggesting pro and counterarguments)?
- How often do you encourage your students to find more than one solution for a problem?
- How often do you encourage your students compare different results?
- How often do you encourage your students to explain a finding?
- How often do you encourage your students to analyse information from different sources?
- How often do you encourage your students to evaluate a solution to a problem?

4

# 5

# Primary teachers' attitudes towards using new technology and stimulating higher-order thinking in students: A profile analysis

This chapter is based on: Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2022). *Primary teachers' attitudes towards using new technology and stimulating higher-order thinking in students: A profile analysis*. [Manuscript submitted for publication]. Department for Teacher Development, University of Twente.

## Abstract

Critical thinking, creative thinking, problem solving, and other so-called higher-order thinking skills are regarded as crucial for students to develop. Research shows that technology can be used as a tool to stimulate students' higher-order thinking skills. However, most teachers rarely use new technology to stimulate students to engage in higher-order thinking. To help teachers in this, we need to gain an understanding of teachers' *attitudes* towards using new technology and towards stimulating higher-order thinking. In this study, we explore these teacher attitudes by identifying teacher profiles based on primary school teachers' attitudes (N = 659) towards (a) using new technology and (b) stimulating higher-order thinking. Results of the cluster-analysis revealed three teacher profiles. In follow-up focus group interviews with 21 participants, we found that teachers recognized the identified profiles and that the results of the cluster-analysis matched teachers' self-chosen profiles in almost all cases. These results indicate that we can suitably characterize teachers based on their attitudes towards using new technology and stimulating higher-order thinking. Identification of these profiles may help us understand why certain groups of teachers may use new technology to stimulate students' higher-order thinking, while other teachers might not. This might provide starting points for tailored teacher professionalization for different groups of teachers.

## 1. Introduction

Critical thinking, creative thinking, problem solving, and other so-called higher-order thinking skills are regarded as very important for students to develop (Conklin, 2012; Driana & Ernawati, 2019). Students may actively construct knowledge and become involved in meaningful learning when they engage in higher-order thinking (Anderson et al., 2001). Researchers argue that explicit teaching of higher-order thinking is necessary, since students may not become good thinkers without support (Elder, 2003; Schulz & FitzPatrick, 2016). Thus, teachers need to offer experiences to students that challenge them to engage in complex cognitive skills (e.g., analysing, evaluating, creating) (e.g., Wijnen et al., 2021a; King et al., 1998).

Higher-order thinking can be stimulated in different ways. For example, by answering teacher and/or student generated questions, reflecting on dilemma's and coming up with self-generated solutions for a problem. Furthermore, letting students work together in small groups and stimulating activities, such as group discussion, peer tutoring, and cooperative learning, are effective methods for engaging students in higher-order thinking (King et al., 1998; Singh et al., 2018).

Research shows that technology can be used as a tool to support students' learning, including stimulating their higher-order thinking skills (Backfish et al., 2020; Mayer, 2019). Teaching with technology allows for making use of the technologies' 'affordances', which provides opportunities to enrich the learning environment (Ottenbreit-Leftwich et al., 2018). For example, by enhancing students' (online) collaborative skills (e.g., via social media), or by simulating authentic problems or (aspects of) the physical world (e.g., via games augmented, virtual reality) in which skills, such as exploring, planning, designing, and creating solutions, might be practiced (Araiza-Alba et al., 2021; Chiang et al., 2014; Dede, 2000; Tangkui & Keong, 2020). *New* technology, such as augmented reality, virtual reality, and games have been found to advance students' higher-order thinking, compared to teaching methods that do not include such technologies (Araiza-Alba et al., 2021; Chiang et al., 2014; Passig et al., 2016; Tangkui & Keong, 2020). In section 1.2.2. we explain how we understand new technology in this study.

Most teachers make little use of *new* technology to support students' learning (Fraillon et al., 2018; Ottenbreit-Leftwich et al., 2018) and rarely use technology to stimulate students' higher-order thinking (Backfish et al., 2020; Fraillon et al., 2013; Voogt et al., 2016). To help teachers use new technology to stimulate higher-order thinking, we need to gain an insight into teachers' *attitudes* towards using new technology *and* towards stimulating higher-order thinking. The importance of attitude has been emphasized in many studies (e.g., Howe & Krosnick, 2017; Vögel & Wanke, 2016). Attitude impacts a persons' intention and behaviour and how a person processes information (Vögel & Wanke, 2016). Furthermore, attitude-based professionalization has been found to have a positive impact on teachers' teaching behaviour in other contexts such as science education (Van Aalderen-Smeets & Walma van der Molen, 2015). More specifically, research shows that teachers' attitudes towards using technology in teaching impacts teachers' technology use (e.g., Bowman et al., 2020; Farjon et al., 2019). Similarly, teachers' attitudes towards stimulating higher-order thinking impact teachers' teaching practices (Wijnen, Walma van der Molen, & Voogt, 2021a).

In this study, we investigated whether primary teachers can be categorized into different clusters, or 'profiles', based on their attitudes towards new technology use and their attitudes towards stimulating higher-order thinking. Identification of teacher profiles could give us a better understanding of how different teachers view the use of new technology and stimulating higher-order thinking in students and to what extent this impacts their teaching. This might help us understand, whether, how and why teachers use new technology and/or stimulate students' higher-order thinking. Furthermore, identification of such profiles could provide insight in the needs for teacher support for different groups of teachers, which may allow us to develop teacher-tailored professionalization that fit these needs. To our knowledge, there are no studies in which teachers' attitudes towards new technology use and stimulating higher-order thinking are simultaneously investigated.

## 1.1. Aim of the study

Based on the considerations above, we aimed to answer two research questions in this study: (a) which teacher profiles can be identified, based on teachers' attitudes towards using new technology in teaching and towards stimulating higher-order thinking in students? and (b) do teachers recognize the identified profiles?

To identify teacher profiles, we combined measurements of several attitudinal perceptions (see Table 1 and Table 2 for an overview of the scales) and evaluated to what extent participants scored similarly or differently on these measurements. Varying (mean) scores on multiple scales resulted in different profiles, i.e., different clusters of teachers.

We measured primary school teachers' attitudes towards (1) stimulating higher-order thinking in students and (2) using new technology in teaching with two separate surveys. We see two important reasons for measuring these attitudes separately. First, teachers may differ in their attitudes towards using new technology and stimulating higher-order thinking (Cheeseman, 2018, Önal et al., 2017; Prieto et al., 2016; Schulz & FitzPatrick, 2016). Second, research shows that these attitudes are made up of different attitudinal factors (Wijnen et al., 2021b). For example, in the context of stimulating higher-order thinking, studies indicate that teachers may believe that stimulating higher-order thinking may not be suitable for low-achieving students (e.g., Zohar et al., 2001), whereas in the context of technology use such beliefs did not come up in research.

After measuring these attitudes separately, we conducted a cluster analysis to identify teacher profiles. Identifying teacher profiles based on teachers' views and use of *technology* is not new. In 2017, Admiraal et al., identified five types of teachers based on their beliefs regarding teaching and technology use. In 2021, Howard et al., identified teacher profiles based on teachers' perceptions regarding their readiness to transition to online teaching. In 2022, Admiraal identified teacher profiles based on teachers' use of Open Educational Resources (OER). To our knowledge, however, there are no studies in which teacher profiles are identified based on teachers' attitudes towards stimulating higher-order thinking in students with or without the use of technology. Furthermore, the above-mentioned studies were conducted with secondary school teachers, while our study focuses on primary education.

## 1.2. Definitions

### *1.2.1. Stimulating higher-order thinking*

Anderson et al. (2001) revised Bloom's well know taxonomy of cognitive processes. They distinguished between lower-order thinking skills (remembering, understanding and applying) and higher-order thinking skills (analysing, evaluating, and creating). King et al., (1998) state that successful application of higher-order thinking, like critical, reflective and creative thinking, should result in some outcome (e.g., a decision, explanation, or product). Furthermore, engaging in higher-order thinking fosters the development of these thinking skills in students (King et al., 1998).

To define *stimulating* higher-order thinking, since we focus on the role of the teacher, we used the descriptions of King et al., (1998) and Bloom's revised taxonomy (Anderson et al., 2001). This resulted in the following definition: "stimulating higher-order thinking in students means offering assignments, questions, problems or dilemmas where students need to use complex cognitive skills (such as analysing, evaluating and creating) in order to find a solution or make a decision, prediction, judgement or product" (cf. Wijnen, Walma van der Molen, & Voogt, (2021b, p. 5).



### *1.2.2. New technology*

The term *new* technology is difficult to define because whether something is new, differs between people and contexts and may therefore have a different meaning for different people. Therefore, it is important to take the teachers' perspective and context into account. What is 'new' is dependent upon what technology is available for teachers to use (context), whether and how a teacher believes that a specific technology can be used to support students learning, and whether a teacher is aware of the affordances that specific technologies offer.

Although teachers use different forms of technology in their teaching, such as computers and digital whiteboards (Smeets & Van der Horst, 2018), the implementation of 'new' technologies such as virtual reality, educational robots, and 3D-printers is still not very common (Fraillon et al., 2018) even though these technologies provide opportunities to enhance students' learning (Backfish et al., 2020). These results might indicate that many teachers are unaware of the opportunities that various technologies provide to enrich the learning environment, or that they are unsure how such technologies can be used to enhance student learning.

To define 'new technology' in this study, we decided to focus on the use of technology to support students' learning. Furthermore, we provided examples of technologies that are not often used by (Dutch) teachers (Smeets, 2020; Voogt et al., 2016). These studies show that teachers mainly use the interactive whiteboard to support their instruction and hardly use other technologies (e.g., robots, virtual reality) to enhance their teaching practices. This resulted in the following description: "New technology refers to hardware and software that teachers can use to support and/or enrich their teaching practices. Some examples of hardware are: smartphones, tablets, 3D printers and educational robots (BeeBot, DASH). Software examples are: simulation software, design software, programming software and video-editing software." (Wijnen et al., 2021b, p. 4). This description was presented to primary school teachers to evaluate to what extent it fits teachers' perception of the term new technology.

### *1.2.3. Attitude*

According to Ajzen (2001), "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). An attitude-object is the entity about which an attitudinal evaluation is made (Ajzen, 1991, 2001). In this study, there are two attitude-objects, namely 'using new technology in teaching' and 'stimulating higher-order thinking in students.'

Based on the Theory of Planned Behaviour (TPB; Ajzen, 1991, 2001), we view attitude as an umbrella term that consists of three dimensions. These dimensions can be comprised of subcomponents, which together form a person's attitude towards a specific behaviour (cf. Wijnen et al., 2021b). The *perceptions of behavioural attributes* dimension refers to beliefs and feelings a person may associate with a specific behaviour, in this case, using new technology in teaching and stimulating students' higher-order thinking, respectively. The *perceptions of social norms* dimension refers to a person's perceived social acceptability of the behaviour. The *perceptions of behavioural control* dimension refers to a person's perceived level of control he/she has in performing the behaviour. These perceptions can refer to external factors (e.g., availability of time or resources) or internal factors (e.g., perceived capability of performing the behaviour, often described as "self-efficacy", based on Bandura's concept) (Ajzen, 2002; Armitage & Conner, 2001).

A person's attitude can influence a person's intention to engage in a specific behaviour, which is assumed to impact actual behaviour (Ajzen, 1991). To explore the relationship between the different attitudinal profiles and teacher behaviour, we therefore also included measures of teachers self-reported behaviour related to new technology use and to stimulating higher-order thinking in their students.

# 2. Method

## 2.1. Data collection and analysis

For this study, data was collected in two stages. In the first stage, two questionnaires were administered to a large group of primary school teachers in the Netherlands. With this data, we conducted a cluster-analysis to identify teacher profiles based on their attitudes towards (1) using new technology in teaching, and (2) stimulating higher-order thinking. In the second stage, we conducted follow-up focus group interviews with several teachers who also completed the questionnaires.

## 2.2. Stage 1: Identifying teacher profiles

### *2.2.1. Participants and procedure*

Two questionnaires (see 2.2.2.) were administered simultaneously to a large group of third- and fourth-year pre-service (*N* =257) and in-service primary school teachers (*N* = 402) in the Netherlands. The effective sample size consisted of 136 (20.6%) males and 523 (79.4%) females. Participants' age ranged from 18 to 65 years old (*M* = 29.52, *SD* = 12.69).

Primary schools (in-service teachers) and teacher education colleges (pre-service teachers) were visited by one of the researchers. After a brief introduction and giving informed consent, teachers were directed to an online (84.2%) or paper-and-pencil version (15.8%) of the questionnaires. It took participants approximately 25 minutes to complete both questionnaires. In a few cases, having the researcher visit the school was not possible. Therefore, a small number of participants received an email with a link to redirect them to the online version of the questionnaires.

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### *2.2.2. Instruments*

*The TANT (*Teachers' Attitudes towards New Technology*) questionnaire.* The TANT questionnaire measures (pre- and in-service) primary school teachers' attitudes towards using new technology in teaching. The TANT questionnaire meets the requirements for construct validity and measurement invariance (Authors).

This questionnaire consists of six scales representing six attitudinal factors. Table 1 provides an overview of these scales. The items are measured with a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. In addition, the TANT questionnaires includes a scale on self-reported new technology use (Composite Reliability = 0.81) which consists of seven items such as: How often do students use new technology to work on challenging problems (such as designing gymnastics gear) in your lessons? These items were measured with a 7-point Likert scale ranging from (1) never to (7) every day.

*The SHOT (*Stimulating Higher-Order Thinking) *questionnaire.* The SHOT questionnaire measures (pre- and in-service) primary school teachers' attitudes towards stimulating higher-order thinking in students. The SHOT questionnaire meets the requirements for construct validity and measurement invariance (Wijnen et al., 2021a).

This questionnaire consists of four scales, which represent four attitudinal factors. Table 2 provides an overview of these scales. The items are measured with a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. In addition, the SHOT questionnaire contains two scales to measure teachers' self-reported behaviour related to stimulating higher-order thinking. Teacher Activities (TA; 3 items, Composite Reliability = 0.91) refers to different activities a teacher can undertake to stimulate higher-order thinking (e.g., design a lesson, teach a lesson, give assignments). Encouraging Students (ES; 2 items, Composite Reliability = 0.88) refers to activities to encourage students to engage in different complex thinking processes (e.g., problem solving, creating new products). These behavioural scales were measured with a 7-point Likert scale ranging from (1) never to (7) every day.

### *2.2.3. Analyses*

To identify teacher profiles, we conducted a cluster-analysis. For this analysis we used the unweighted average scores of the six attitudinal scales of the TANT questionnaire and the unweighted average scores of the four attitudinal scales of the SHOT questionnaire. We conducted a hierarchical and follow-up k-means cluster analysis, using SPSS version 24.0.

To identify how many potential clusters there were in the data, we conducted a hierarchical cluster analysis using Ward's linkage and the squared Euclidian distance measure (Allen & Goldstein, 2013; Sarstedt & Mooi, 2019). Next, we calculated the Variance Ratio Criterion (VRC; Calinski & Harabasz, 1974) to explore which number of clusters best fit our data. The number of clusters that maximizes the VRC indicates the appropriate number of clusters. Since VRC usually decreases with an increasing number of clusters, we also calculated the w which refers to the relative loss of variance explained by using less clusters. Therefore, the most optimal number of clusters has the highest VRC and the lowest w (Calinski & Harabasz, 1974).

**Table 1** Scales and items of the TANT questionnaire

| Scale | Description | Example item | Composite reliability |
|---|---|---|---|
| Perceived Relevance | Refers to teachers' beliefs about the importance of using new technology in their teaching in order to prepare learners for later life. | I think it is very important for the future of learners that they get the opportunity to learn how to work with new technology at school | 0.77 |
| Perceived Usefulness | Refers to teachers' beliefs about the usefulness of new technology for improving and/or enriching their teaching and the learning of their students. | I think that, with the help of new technology, I can vary more in the assignments I offer my learners | 0.70 |
| Perceived difficulty | Refers to teachers' beliefs and related feelings of anxiety about the difficulty of using new technology in teaching. | I think it is very difficult to use new technology in my lessons | 0.86 |
| Self-efficacy | Refers to teachers' self-perceived capability to use new technology in their teaching. | I am well able to choose new technologies that support the lesson content of the subjects I teach | 0.86 |
| Context-dependency | Refers to teachers' *perceptions* that external factors, such as the availability of technical resources, on-site support, and available time, are *a prerequisite* for them to be able to use new technology. | For me, the availability of content support, in the form of an ICT-coordinator, determines whether I use new technology in my lessons | 0.72 |
| Subjective Norm | Refers to teachers' perceptions as to whether other people who are important to that teacher think it is good or bad to use new technology in teaching. | I have the feeling that using new technology in lessons is appreciated by colleagues and management at our school | 0.77 |

Table 2  Scales and items of the SHOT questionnaire

| Scale | Description | Example item | Composite reliability |
|---|---|---|---|
| Perceived Relevance | Refers to teachers' beliefs about the importance of stimulating higher-order thinking for students' personal development. | I think it is essential for the learning of students that they are encouraged to engage in higher-order thinking | 0.90 |
| Perceived Student Ability | Refers to teachers' beliefs about whether higher-order thinking is suitable for both low- and high-achieving students. | I think that assignments that require higher-order thinking are more appropriate for 'smart' students than for 'weak' students | 0.81 |
| Self-efficacy | Refers to teachers' self-perceived capability to stimulate higher-order thinking in students. | I am well able to guide students in doing assignments that stimulate them to engage in higher-order thinking | 0.90 |
| Context-dependency | Refers to teachers' perception that external factors, such as available time, or support are a *prerequisite* for them to be able to stimulate higher-order thinking in students. | For me, making higher-order thinking assignments is only possible when I have a method that describes how to do that | 0.73 |

After determining the optimal number of clusters, we conducted a k-means cluster analysis to identify groups of participants that score similarly on the TANT and SHOT questionnaire. To determine the stability of the cluster solution, the k-means analysis is performed on an approximately 50% random sample of the 659 participants and the outcome of this analysis is compared to the outcome of the k-means analysis on the full sample. Furthermore, k-means was performed multiple times where the ordering of objects (e.g., participants scores) was varied to evaluate whether the resulting clusters remained similar. Lastly, we performed a One-way ANOVA to explore differences between the clusters, which allowed us to identify different 'types' of teachers.

### 2.4. Stage 2: Understanding teacher profiles

#### *2.4.1. Participants and procedure*

After identifying teacher profiles, we conducted five follow-up focus group interviews with 14 in-service and 7 pre-service primary school teachers. For the selection of participants, we evaluated at what schools or teacher education colleges a specific profile was strongly represented. We selected participants from those schools and teacher education colleges to ensure a representation of all groups in the focus group interviews.

Due to the outbreak of the Covid-19 pandemic, only the first focus group interview took place in a face-to-face setting. The other focus group interviews were conducted digitally with Microsoft Teams. The interviews were audio recorded. The procedure was similar in both settings. After giving informed consent, the interviewer gave an introduction about the procedure of the interview. Next participants received a description of the three identified profiles (Appendix A) and were asked to fill in a short open-ended questionnaire about these profiles (Appendix B). Then the semi-structured interview started. These interviews took approximately 25 minutes.

#### *2.4.2. Analyses*

To analyse the interview data, we created an overview of the participants' answers of the questionnaire and transcribed all recordings of the focus group interview. With this data we aimed to answer the question: to what extent do participants recognize themselves in the profiles that were identified with the cluster analysis? In addition, we evaluated whether the teacher's own choice of profile matched the results from the cluster analysis. To do this, we requested that participants made a code for both the TANT- and SHOT-questionnaire as well as the open-ended questionnaire that was used in the interviews. This way, we were able to compare the results from the cluster-analysis with the teachers' own chosen profiles.



## 3. Results

### 3.1. Stage 1: Identifying teacher profiles

Inspection of the resulting dendrogram of the hierarchical cluster analysis, indicated that a three-cluster solution might be suitable. In addition, the VRC score was the highest, VRC = 1556.945 and $\omega$ the lowest, $\omega$ = -217.023 for the three-cluster solution, indicating that three is the most optimal number of clusters for our dataset. Results of the comparison of 50% of the sample with the full sample showed that the maximum relative difference in cluster size is 5.4%, which is below the threshold of 20% (Sarstedt & Mooi, 2019). Furthermore, the multiple k-means analyses where the ordering of objects was varied, showed that the variation between the different cluster-solutions was less than 0.2%, indicating a very stable cluster solution.

To identify different types of teachers, we conducted a One-way ANOVA, using the cluster number (e.g., to which cluster the participant belongs) as the grouping variable. For this analysis we included the behavioural factors (new technology use and stimulating higher-order thinking: teaching activities and encouraging students). The One-way ANOVA showed significant differences between the clusters on all variables. A Bonferroni post-hoc analysis was conducted to explore on which variables there were differences between the clusters (see table 3). Based on these scores we distinguished three profiles of teachers.

**Table 3** Average mean scores on the attitudinal and behavioural scales per cluster

| | Profile 1 | | Profile 2 | | Profile 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | N= 197 | | N= 330 | | N= 131 | | N = 658 | |
| **TANT questionnaire** | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Perceived relevance | **4.27** | 0.555 | 3.95 | 0.660 | 3.79 | 0.760 | 4.01 | 0.676 |
| Perceived usefulness | **4.09** | 0.711 | 3.62 | 0.743 | 3.57 | 0.724 | 3.75 | 0.762 |
| Perceived difficulty | <u>1.97</u> | 0.632 | **2.94** | 0.655 | 2.58 | 0.716 | 2.58 | 0.783 |
| Self-efficacy | **3.19** | 0.709 | 2.58 | 0.614 | 2.65 | 0.639 | 2.78 | 0.701 |
| Context dependency | <u>2.69</u> | 0.891 | **3.68** | 0.730 | 3.08 | 0.795 | 3.27 | 0.907 |
| Subjective norms | **3.35** | 0.771 | 3.17 | 0.704 | <u>2.71</u> | 0.779 | 3.13 | 0.772 |
| New technology use* | **2.42** | 1.043 | 2.02 | 0.921 | 1.92 | 0.464 | 2.12 | 0.912 |
| **SHOT questionnaire** | | | | | | | | |
| Perceived relevance | **4.22** | 0.591 | 3.80 | 0.587 | <u>2.07</u> | 0.491 | 3.58 | 0.961 |
| Perceived student ability | 1.89 | 0.617 | **2.62** | 0.738 | 1.98 | 0.416 | 2.27 | 0.737 |
| Self-efficacy | **3.55** | 0.652 | 3.14 | 0.619 | <u>1.98</u> | 0.409 | 3.03 | 0.811 |
| Context dependency | 2.13 | 0.651 | **2.98** | 0.600 | 2.04 | 0.459 | 2.54 | 0.738 |
| Stimulating HOT, TA* | **3.48** | 1.475 | 2.84 | 1.313 | <u>2.01</u> | 0.590 | 2.86 | 1.357 |
| Stimulating HOT, ES* | **4.52** | 1.576 | 4.13 | 1.622 | <u>2.25</u> | 1.084 | 3.87 | 1.725 |

a. **Bold**: significantly higher score on the scale compared to other profiles
b. <u>Underlined</u>: significantly lower score on the scale compared to other profiles
c. *Measured on a 7-point Likert scale: 1. Never, 2. A few times a year, 3. Once a month, 4. A few times a month, 5. Once a week, 6. A few times a week, 7. Every day.
d. TA = Teaching Activities, ES = Encouraging Students.

*Profile 1.* Teachers in profile 1 believe that using new technology is very important, and that new technology is a useful tool to enrich their teaching. Furthermore, these teachers do not think that using new technology is difficult and feel reasonably capable in using new technology. These teachers feel somewhat dependent upon context factors such as technical support and feel somewhat supported by their colleagues and the school director. These teachers use new technology approximately a few times a year to once a month.

Furthermore, teachers in profile 1 believe that is important to stimulate higher-order thinking. These teachers think that higher-order thinking is appropriate for both 'smart' and 'weak' students, feel capable in stimulating higher-order thinking and do not feel dependent upon context factors such as a method to be able to stimulate higher-order thinking. These teachers stimulate higher-order thinking once a month to once a week, where they focus mostly on encouraging students to engage in higher-order thinking.

*Profile 2.* Teachers in profile 2 believe that it is important to use new technology, and that it can be a useful tool to enrich their teaching. However, these teachers think that it is not easy to use new technology, feel dependent on context factors such as technical support and do not feel very capable in using new technology. Also, they do not feel encouraged or discouraged by their colleagues and school director to use new technology. These teachers use new technology approximately a few times a year.

Furthermore, teachers in profile 2 think that stimulating higher-order thinking is important, but less strongly than teachers with profile 1. However, they are unsure whether higher-order thinking is suitable for 'weak' learners, feel somewhat dependent on context factors and feel somewhat capable in stimulating higher-order thinking. These teachers stimulate higher-order thinking approximately a few times a year to a few times a month, where they focus mostly on encouraging students to engage in higher-order thinking.

*Profile 3.* Teachers in profile 3 believe that it is important to use new technology, and that it can be a useful tool to enrich their teaching. These teachers think that using new technology is not very difficult, feel somewhat dependent on context factors and do not feel very capable in using new technology. These teachers perceive little support from their colleagues and school director to use new technology and use new technology a bit less than a few times a year.

Furthermore, teachers in profile 3 do not think that stimulating higher-order thinking is very important and do not feel very capable in stimulating higher-order thinking. They do not feel dependent upon context factors such as a method and they do not think that higher-order thinking is more appropriate for 'smart' students.

Teachers with this profile stimulate students' higher-order thinking significantly less often (a few times a year) than teachers with other profiles do.

### *3.1.2. Teacher characteristics per profile*

As can be seen in table 4, profile 2 is the most common profile. Furthermore, it appears that profile 3 is represented almost completely by pre-service teachers. Further analysis on this profile showed that 83.2% of the pre-service teachers in this profile come from the same teacher education college.

**Table 4** Characteristics of participants in each cluster

| | | Profile 1 (N = 197) | | Profile 2 (N = 330) | | Profile 3 (N = 131) | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % |
| Sex | Male | 56 | 28.4 | 60 | 18.2 | 19 | 14.5 | 135 | 20.5 |
| | Female | 141 | 71.6 | 270 | 81.8 | 112 | 85.5 | 523 | 79.5 |
| Teacher type | In-service teacher | 100 | 50.8 | 153 | 46.4 | 4 | 3.1 | 257 | 39.1 |
| | pre-service teacher | 97 | 49.2 | 177 | 53.6 | **127** | **96.9** | 401 | 60.9 |

## 3.2. Stage 2: Understanding teacher profiles

To gain a more in-depth understanding of the identified profiles we conducted follow-up focus group interviews. As described in section 2.4.1., we selected schools and teacher education colleges where a certain profile was strongly represented. However, participants from the teacher education college where profile 3 was strongly represented were unable to participate in the focus group interviews. Therefore, only participants from schools and teacher education colleges where profile 1 and 2 were strongly represented, participated in the interviews.

### *3.2.1. Matching profiles*

We evaluated whether teachers' own choice of profile matched the results from the cluster-analysis. Therefore, we analysed the answers participants gave in response to the question: Which profile fits you best? Because some participants did not include a code for either the TANT- SHOT or open-ended questionnaire we could only match the results for 14 out of 21 participants. For 13 of the 14 participants, the chosen profile matched the results of the cluster-analysis. This means that if according to the cluster analysis a participant belonged in a certain profile, the teacher also selected that profile as the best fitting profile.

### *3.2.2. Recognizing profiles*

*Profile 1.* We found that 11 in-service teachers and 2 pre-service chose profile 1 because they recognized themselves in a number of characteristics of this profile (see table 5). The characteristic that they mentioned most was that stimulating HOT is important for *all* students, both weak and smart. Furthermore, teachers mentioned that using new technology in teaching is very important to prepare students for the future. In one of the interviews a participant explained: "… I find it very important that you prepare students for the future, because the future is all about new technologies."

Next, participants explained which, if any, characteristics they did not recognize (see Table 6). The participants did not recognize the characteristic of profile 1 that no technical support was needed. Five participants indicated that sometimes they do need ICT- or technical support.

**Table 5** Characteristics that participants (N=13), who chose profile 1 recognized

| | |
|---|---|
| Stimulating HOT is suitable for *all* students | 8 |
| Using new technology is very important to prepare students for the future | 5 |
| New technology is a useful tool to enrich and stimulate students' learning | 4 |
| Stimulating HOT is very important | 3 |
| Using new technology in teaching is not very difficult | 2 |
| The use of new technology is stimulated by colleagues and school director | 2 |
| I do not need a method or ready-made materials to be able to stimulate students' HOT | 2 |
| I feel capable in the use of new technology | 1 |
| I use technology often in my lessons | 1 |

**Table 6** Characteristics that participants (N=13), who chose profile 1, did not recognize

| | |
|---|---|
| I *do (sometimes) need* technical support to be able to use new technology in my lessons | 5 |
| I think that the use of new technology *is not* very appreciated by my colleagues | 3 |
| I *do not* always feel capable in stimulating HOT in my students | 2 |
| Using new technology *is* difficult | 1 |

5

We asked teachers with profile 1 about their new technology use, because the results from the cluster-analysis showed that even though these teachers are positive about using new technology, their actual use is limited. Six participants explained that they mainly use drill-and-practice (digital flashcards) and quiz-software. They had an interactive whiteboard and tablets available to work with this software.

*Profile 2*. We found that 3 in-service teachers and 5 pre-service teachers recognized themselves mostly in profile 2. Five participants mentioned that they recognized the characteristic 'not feeling very capable in using new technology in teaching.' Furthermore, four participants mentioned that they find it important to use new technology to prepare students for their future (see Table 7).

**Table 7** Characteristics that participants (N=8) who chose profile 2 recognized

| | |
|---|---|
| I do not feel very capable in using new technology in my teaching | 5 |
| Using new technology is important to prepare students for the future | 4 |
| It is important to stimulate HOT in students | 2 |
| New technology can be a useful tool to enrich and stimulate students' learning | 1 |
| I need some explanations before I dare to use new technology in my teaching | 1 |
| I sometimes need technical support | 1 |
| I need a method to stimulate HOT in students | 1 |
| I am unsure whether 'weak' students are capable in HOT | 1 |

In response to the question which characteristics they did not recognize, three participants answered that they believed that the use of new technology was encouraged by colleagues and the school director. Furthermore, three participants mentioned that they believe that stimulating HOT is important for both 'weak' and 'smart' students (see Table 8).

**Table 8** Characteristics that participants (N=8), who chose profile 2, did not recognize

| | |
|---|---|
| I believe that new technology use is encouraged by colleagues and the school director | 3 |
| I think that stimulating HOT is important for 'weak' and 'smart' students | 3 |
| Colleagues are sometimes hesitant to use new technology, but this might be caused by a lack of knowledge | 1 |
| Colleagues don't always appreciate creative (HOT) lessons | 1 |

## 5. Conclusions and discussion

In this study, we aimed to answer two research questions, namely (a) which teacher profiles can be identified based on teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students? And (b) do teachers recognize the identified profiles?

### Teacher profiles

The results of our cluster-analysis revealed three profiles based on teachers' attitudes towards using new technology and stimulating students' higher-order thinking. Furthermore, in follow-up focus group interviews we found that most participants were able to select a profile because they recognized themselves in one of the profiles. Also, the results of the cluster-analysis matched the teachers' self-chosen profiles in almost all cases. These results indicate that we can suitably characterize teachers based on their attitudes towards using new technology and stimulating higher-order thinking.

We found that teachers, irrespective of their profile, make little use of new technology and/or do not stimulate higher-order thinking in students very often. This is in line with previous research (Backfish et al., 2020; Fraillon et al., 2013; Voogt et al., 2016). The three identified profiles suggest that the reasons for the limited use of new technology and limited stimulation of students' higher-order thinking may be different for different groups of teachers. This indicates that it might be necessary to tailor teacher professionalization to the needs of different groups of teachers.

#### *Profile 1*

Teachers in profile 1 can be characterized as teachers with a positive attitude towards using new technology and towards stimulating higher-order thinking. These teachers stimulate students' higher-order thinking significantly more often than teachers in the other profiles, with a main focus on encouraging students to engage in complex thinking (approximately a few times a month to once a week). However, despite their positive attitudes towards using new technology, teachers in profile 1 still make very little use of new technology in their teaching (approximately a few times a year). This implies that when teachers stimulate pupils' higher-order thinking, they predominantly do so with teaching materials or assignments that do not include new technology.

When profile 1 teachers use technology, they mainly seem to use common technology to stimulate students' *lower*-order thinking. During the interviews, teachers mentioned that they use drill-and-practice software and quiz-software to have students remember facts and check whether and how many students know the right answer on a specific question. This focus on using common technology for *lower*-order thinking is in line with other research (O'Neal et al., 2017; Smeets, 2020).

Since teachers in profile 1 have positives attitude towards using new technology and stimulating higher-order thinking, we hypothesize that attitude-focused professionalization may be less important for this group of teachers compared to teachers in other profiles. Instead, support for teachers in profile 1 might be focused on acquiring knowledge and skills about *how* new technology can be used for stimulating students' higher-order thinking. This might be done by providing examples of new technology use for stimulating students' higher-order thinking or by letting them plan and execute lessons in which they use new technology to stimulate students' higher-order thinking.

*Profile 2*

In our sample, most teachers were categorized in profile 2. Teachers in this profile believe new technology is important and that it is a useful tool to enrich their teaching. However, they think that it is difficult to use new technology, feel dependent upon context factors (such as technical support) and do not feel very capable in using new technology, which might explain their limited use of new technology (approximately a few times a year). Furthermore, these teachers believe that it is fairly important to stimulate higher-order thinking in students but are unsure whether this is suitable for low-achieving students and feel dependent upon context-factors (such as ready-made materials) to be able to stimulate higher-order thinking. These teachers engage in teaching activities aimed at stimulating higher-order thinking a bit less than once a month and encourage students to engage in complex thinking approximately a few times a month. Since these teachers make little use of new technology in their teaching, and only occasionally stimulate students' higher-order thinking, we suspect that these teachers rarely use new technology for stimulating higher-order thinking.

Based on these findings we hypothesize that it is important to focus support for teachers in profile 2 on enhancing their self-efficacy and lowering their feelings of dependency on context factors. Bowman et al., (2020) found that both teachers' ability beliefs (e.g., self-efficacy) and value beliefs (e.g., attitude and perceived usefulness of technology) impact technology integration aimed at engaging students in both lower-order and higher-order thinking. Teachers in profile 2 already have reasonably high value beliefs, so it seems important to focus on improving their ability beliefs. This might be done by engaging teachers in attitude-focused professionalization. In such professionalization the focus might be on increasing feelings of confidence and raising awareness about teachers own attitudes. For example, teachers in profile 2 might believe that using new technology is 'just hard' and 'I can't use it'. By explicitly paying attention to such perceptions by asking questions such as: 'why do you think you can't use it?' 'What does it mean if you can't?' 'What if you could?' 'Can you learn how to use it? 'What would you need for that?' teachers may become aware of and challenge their perceptions. Such strategies, along with allowing teachers to practice in a safe environment, receiving feedback from an expert on their use of new technology and stimulation of higher-order thinking and providing examples and materials that teachers can use and explore might help them develop more positive attitudes. In the context of science teaching, such attitude-focused professionalization has proven to be successful in increasing feelings of self-efficacy and lowering feelings of context-dependency (Van Aalderen-Smeets & Walma van der Molen, 2015) and might be useful in this context as well.

*Profile 3*

Teachers in profile 3 can be characterized as teachers who have a neutral attitude towards using new technology in teaching and a negative attitude towards stimulating higher-order thinking. These teachers do not think that it is very important to stimulate higher-order thinking, do not feel capable in stimulating higher-order thinking, and rarely stimulate students' higher-order thinking (approximately a few times a year). Furthermore, they do not feel very encouraged by their colleagues and school director to use new technology. Based on the results regarding the limited use of new technology and stimulating higher-order thinking, we suspect that these teachers very rarely use new technology for stimulating students' higher-order thinking.

In our sample, teachers in profile 3 were almost all pre-service teachers from the same teacher education college. This is interesting, because this suggests that the educational program these pre-service teachers follow might impact their attitudes. Tondeur et al., (2012) identified 12 strategies that need to be in place in teachers' educational program to prepare future teachers to use technology. Six of these strategies are related to preparing pre-service teachers at the micro-level: (1) using teacher educators as role models, (2) letting students reflect on digital applications in teaching and learning processes, (3) learning how to use technology by design, (4) collaborating with peers, (5) scaffolding authentic knowledge experiences (6) providing ongoing feedback. In a follow-up study, Tondeur et al., (2018) found that when pre-service teachers perceive more of the occurrences of these six themes during their pre-service training, they report higher competencies in using ICT for learning. Furthermore, Tiba and Condy (2021) found that if pre-service teachers can work with technology during workshops as part of the educational program and if there are technological resources available at the teacher education college, this can impact pre-service teachers' readiness to use technology. Additionally, Baran et al., (2017) found what teacher educators do, for example whether they serve as a role model, can impact pre-service teachers' beliefs about the value of technology integration. This can result in more positive attitudes about technology integration. These findings indicate that a teacher education program and the actions of teacher educators can impact pre-service teachers' attitudes and/or use of technology in their teaching.

Although, we were unable to find studies that explore whether pre-service teachers' attitudes towards stimulating higher-order thinking might be impacted by the educational program and teacher educators, it seems reasonable to think that whether and how much attention is paid to stimulating higher-order thinking in an educational program and to what extent teacher educators encourage pre-service teachers to stimulate higher-order thinking in their students might impact their attitudes towards stimulating higher-order thinking.

To support teachers in profile 3, it seems important to gain a better understanding about why these teachers have a negative attitude towards stimulating higher-order thinking and whether and to what extent this might be related to the educational program these teachers follow. Support might be incorporated in the educational program and/or teacher educators might be supported in how to teach pre-service teachers about the use of new technology and stimulating higher-order thinking.

## Critical reflections and recommendations for future work

As described in the introduction, we had several reasons to measure teachers' attitudes towards using new technology and stimulating higher-order thinking separately. In addition, we measured teachers self-reported behaviour related to their new technology use and practices to stimulate students' higher-order thinking. Based on our findings we suspect that the teachers with different profiles make little use of new technology *for* stimulating higher-order thinking. However, we did not measure this directly. Therefore, some behavioural scales related to using common technology for both lower- and higher-order thinking and using new technology for stimulating both lower- and higher-order thinking might be included in a future study. By adding such scales, we can gain insight into how often teachers use common and new technology and to what extent they use such technologies for stimulating lower- and higher-order thinking in students.

Although it is promising that the participants in our follow-up focus group interviews found the profiles recognizable and that the results of the cluster-analysis matched the teachers' self-chosen profiles in almost all cases, we do not have enough data to validate the profiles that we identified. We suggest that researchers in the future validate the profiles we identified in this study by conducting additional interviews. Such interviews might help in gaining a better understanding of *why* teachers fall into these categories.

This study was conducted just before and at the start of the Covid-19 pandemic. The pandemic caused many teachers to switch from face-to-face to online teaching. Although switching to online teaching does not necessarily mean that teachers use new technology to support and enrich students' learning, it may have affected their perspectives regarding the use of new technology in teaching as well as their perspectives on engaging students in higher-order thinking. However, we do not yet know whether and how this switch to online teaching impacts teachers' attitudes towards using new technology or stimulating higher-order thinking, and whether this effect is similar for teachers with different profiles. The present study may be replicated to explore possible changes in teachers' attitudes.

The profiles that we identified in this study are based on both pre- and in-service teachers' attitudes towards new technology use and stimulating students' higher-order thinking. These teachers are nested within schools and teacher education colleges and research shows that factors such as school culture and available support can impact teachers' attitudes (e.g., Van der Linde et al., 2014). The finding that teachers in profile 3 are almost all from the same teacher education college seems to indicate that such factors are important to consider when studying these teachers' attitudes. Furthermore, pre-service teachers generally have less teaching experience, and this can impact teachers' technology integration (Backfisch et al., 2020). It is important to be aware of factors such as (school) culture and teaching experience since this might have an impact on the strategies that are suitable to support both pre- and in-service teachers in the different profiles.

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## Appendix A: Profile descriptions handed out to participants during the focus group interviews

### Profile 1: Ellen

Ellen thinks it is very important to use new technology in her teaching to prepare students well for their future. She thinks that new technology is a useful tool to support and enrich her students learning. She thinks that using new technology is not very difficult and feels reasonably capable in using new technology in her lessons. To do this, she does not necessarily require technical assistance or content support from an ICT-coordinator. Furthermore, she has the feeling that her colleagues and school director appreciate the use of new technology. Ellen uses new technology approximately a few times a year in her lessons.

In addition, Ellen thinks it is very important to stimulate students' higher-order thinking. She thinks that this is important for *all* students, both 'strong' and 'weak' students. She feels reasonably capable in stimulating higher-order thinking in her students and does not necessarily need a method or ready-made materials to do this. On average, she pays attention to stimulating students' higher-order thinking a few times a month

### Profile 2: Barbara

Barbara thinks it is important to use new technology in her teaching to prepare students well for their future. She also thinks that new technology can be a useful tool to support and enrich her students learning, but she also thinks that is sometimes pretty difficult to use new technology and she needs technical support and help from the ICT-coordinator to do this. She does not feel very capable to use new technology in her lessons. Furthermore, she has the feeling that her colleagues and school director are quite neutral about the use of new technology, it is not disapproved but also not encouraged. Barbara uses new technology approximately a few times a year in her lessons.

In addition, Barbara thinks it is important to stimulate students' higher-order thinking. She feels reasonably capable to do this but is unsure whether higher-order thinking can also be stimulated in 'weak' students. She is also in need of a method and ready-made materials that she can use to stimulate higher-order thinking in students. On average, she pays attention to stimulating students' higher-order thinking once a month.

## Profile 3: Tineke

Tineke thinks that is reasonably important to use new technology in her teaching to prepare students well for their future. She also thinks that new technology can be a useful tool to support and enrich her students learning. She thinks that it can be difficult to use new technology and appreciates technical support or help from the ICT-coordinator, but it is not a condition. She does not feel very capable in the use of new technology in her lessons. Furthermore, she does *not* have the feeling that her colleagues or the school director believe that it is important to use new technology in teaching. Tineke uses new technology approximately a few times a year in her lessons.

In contrast to the use of new technology, Tineke does not think that it is important to stimulate students' higher-order thinking. Also, she does not feel capable to stimulate her students in higher-order thinking, but she also does not need a method or ready-made materials that she can use stimulate students' higher-order thinking. However, she does think that higher-order thinking can be stimulated in both 'strong' and 'weak' students. On average, Tineke stimulates her students to engage in higher-order thinking once a year.

## Appendix B: Questionnaire that participants completed during the focus group interviews

1. Please indicate which profile you think fits you best.

2. Which characteristics in the description fit you best?
   Please explain why you think so.

3. Are there any characteristics in the description that you think fit less well?
   Please explain why you think so.

5

# 6

# Discussion

## Recapitulation and research aim

This dissertation describes the results of four studies on primary school teachers' attitudes towards stimulating higher-order thinking and towards using new technology in teaching. The importance of stimulating so-called higher-order thinking in students is emphasized in many studies (e.g., Conklin, 2012; Driana, & Ernawati, 2019). However, researchers have expressed concerns about the lack of teaching practices that teachers use to explicitly stimulate students' higher-order thinking and the great emphasis that is placed upon mere knowledge transmission that focuses on lower-order cognitive levels (Schulz & FitzPatrick, 2016; Zohar & Cohen, 2016).

Research shows that technology can be used as a tool to support students learning, including higher-order thinking (Backfish et al., 2020; Mayer, 2019). However, most teachers use technology mainly to stimulate *lower-order* thinking (De Aldama & Pozo, 2016; Ertmer et al., 2015; Smeets, 2018; Voogt et al., 2016). In addition, technologies such as augmented reality, virtual reality, and games have been found to support students' learning and advance their higher-order thinking, compared to teaching practices that do not include such technologies (Araiza-Alba et al., 2021; Chiang et al., 2014; Passig et al., 2016; Tangkui & Keong, 2020). We use the term *new technology* for technologies that are considered new for the teachers in our studies. In the Dutch context (where our studies were conducted) teachers do not often use the technologies mentioned above (Smeets, 2020; Voogt et al., 2016) and we therefore expect that most teachers have little experience with these technologies in their teaching. Using technologies such as virtual reality and games in teaching would therefore be *new* for many Dutch primary school teachers.

To support primary school teachers in their use of new technology to stimulate higher-order thinking, it is important that we gain an understanding of teachers' *attitudes* towards using new technology *and* towards stimulating higher-order thinking. However, there is little research on pre- and in-service primary school teachers' attitudes towards stimulating higher-order thinking, and we know little about teachers' attitudes towards using new technology to stimulate higher-order thinking. Therefore, we conducted several studies, described in this dissertation, to fill this void in research. The main research question that we aimed to answer is: What are pre- and in-service primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students?



## Theoretical background

Due to several issues, the literature on teachers' attitudes towards using technology is somewhat 'messy' (Scherer et al., 2020). In research, there are different definitions of the construct attitude. Some definitions describe attitude as emotions that a person can experience, such as pleasure (e.g., Teo, 2015), whereas other definitions describe attitudes as beliefs related to a specific subject or behaviour that a person may hold (e.g., Baek et al., 2017). Furthermore, there are different descriptions of the attitude-object. For example, studies measure teachers' attitudes towards technology in general (e.g., Christensen & Knezek, 2009), rather than their attitudes towards using technology *in teaching*. This is problematic because without a clear definition of attitude and the attitude-object it is difficult to study which attitudinal factors are important to consider if we wish to support teachers in their use of technology.

The literature on teachers' attitudes towards stimulating higher-order thinking is hindered by similar issues as the literature on teachers' attitudes towards technology use. Suspectedly due to the many different descriptions of the term higher-order thinking, there is much variation in the attitude-object that is studied (e.g., teaching thinking: Baysal et al., 2010; improving critical thinking: Alwadai, 2014; creative thinking: Al-Nouh et al., 2014). However, the literature on primary school teachers' attitudes towards stimulating higher-order thinking is hindered by another important limitation, which is that there are very few studies that explore how teachers perceive stimulating higher-order thinking in students, especially on the primary school level (Schulz & FitzPatrick, 2016). We therefore know little about whether teachers find it important to stimulate students' higher-order thinking, whether they feel capable, how they feel when stimulating students' higher-order thinking or whether they think that stimulating higher-order thinking is only appropriate in certain contexts or for certain students.

To help 'clear the messiness,' we went back to one of the core theoretical models of attitude, the Theory of Planned Behaviour (Ajzen, 1991). According to Ajzen (2001), "attitude represents a summary evaluation of a psychological object (the 'attitude-object'), captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (p. 28). Based on this theory, we view attitude as an umbrella term consisting of three dimensions which together form a person's attitude towards a particular behaviour. Each dimension is comprised of attitudinal factors that are specific for each behaviour. The first dimension, *perceptions of behavioural attributes,* represents beliefs and feelings a person associates with the specific behaviour, in this case, teachers' (intended) use of new technology and stimulation of students' higher-order thinking, respectively. The second dimension, *perceptions of social norms*, represents a person's perception of the social acceptability of the behaviour. The third dimension, *perceptions of behavioural control*, represents a person's perception of the level of control he/she has as far as performing the behaviour. These perceptions can refer to external factors (e.g., availability of resources or time) that impact a persons' perception of control, or internal factors, such as perceived capability of performing the behaviour, which is frequently defined as "self-efficacy", based on Bandura's concept (Ajzen, 2002; Armitage & Conner, 2001).

A person's views regarding each of the factors that comprise these three dimensions make up a person's attitude. In turn, a person's attitude may impact a person's intention to perform or not perform a specific behaviour (Ajzen, 1991). It is assumed that the stronger an intention, the more likely it is that the person will enact the behaviour (Ajzen, 1991). We used this conception of attitude in all four studies to gain insight into primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students.

## Main findings

### Systematic literature reviews

In the first study (Chapter 2), we set out to explore the literature to answer two research questions: (R1) What attitudinal factors make up primary school teachers' attitudes towards using technology in their teaching and to what extent do these factors influence teachers' intended or actual use of technology in teaching? (R2) What attitudinal factors make up primary school teachers' attitudes towards stimulating higher-order thinking in their students and to what extent do these factors influence teachers' intended or actual behaviour to stimulate students' higher-order thinking?

Initially, we aimed to study primary school teachers' attitudes towards using technology *for* stimulating students' higher-order thinking. However, this proved to be difficult because there was hardly any literature on this topic. Furthermore, there are theoretical considerations that complicate the simultaneous study of these attitudes. First, teachers may have *differing attitudes* towards technology use and stimulating higher-order thinking. For example, a teacher might have a positive attitude towards technology use, but a negative attitude towards stimulating higher-order thinking, with or without the use of technology. Second, it is possible that *different factors* underlie these teacher attitudes. For example, Zohar et al. (2001) found that most teachers believe that higher-order thinking is more suitable for high-achieving students than for low-achieving students. However, a similar belief has not come up in research on teachers' attitudes towards using technology. Third, because we aimed to explore teachers' attitudes towards *two different behaviours*, it seemed reasonable to assume that different bodies of literature needed to be explored in order get a comprehensive overview. Therefore, we decided to conduct two separate literature reviews.

We used the conception of attitude described above to structure the literature on primary school teachers' attitudes towards using technology in teaching. This resulted in a theoretical framework that describes nine attitudinal factors that make up primary school teachers' attitudes towards using technology in teaching. These factors are described in Table 1. In this literature review we included literature on teachers' attitudes towards different forms of technology, both common and less common technologies. We think that in this way we will get a broad conception of attitudinal factors that impact primary school teachers' use of technology.

Similarly, we used the conception of attitude described above to structure the literature on primary school teachers' attitudes towards stimulating higher-order thinking in students. The resulting theoretical framework describes four attitudinal factors that make up primary school teachers' attitudes towards stimulating higher-order thinking in students. These factors are described in Table 2. However, due to the limited number of studies in which teachers' attitudes towards stimulating higher-order thinking are reported, the framework might not present all relevant attitudinal factors.

**Table 1** Identified attitudinal factors that make up primary school teachers' attitudes towards using (new) technology in teaching

| Factor | Definition |
|---|---|
| Perceived usefulness (PU) | Teachers' beliefs about the usefulness of technology for improving and/or enriching their teaching and the learning of their students. |
| Perceived ease of use (PEU) | Teachers' beliefs about the ease or difficulty of using technology in their teaching. |
| Perceived relevance (PR) | Teachers' beliefs about the importance of using technology in their teaching in order to prepare students for later life. |
| Perceived effect on student motivation (PESM) | Teachers' beliefs that using technology in teaching motivates students to learn and engages students in learning. |
| Anxiety (AX) | Negative feelings such as anxiety or fear when using technology. |
| Enjoyment (EY) | Positive feelings such as enjoyment or enthusiasm when using technology. |
| Self-efficacy (SE) | Teachers' self-perceived capability to use technology in their teaching. |
| Context dependency (CD) | Teachers' perceptions that external factors, (i.e., availability of resources, support, available time) are a prerequisite for them to be able to use technology. |
| Subjective norms (SN) | Teachers' perceptions as to whether other people who are important to that teacher think it is good or bad to use technology in teaching. |

Table 2 Identified attitudinal factors that make up primary school teachers' attitudes towards stimulating higher-order thinking in students

| Factor | Definition |
|---|---|
| Perceived relevance (PR) | Teachers' beliefs about the importance of stimulating higher-order thinking in students in order to help them develop the necessary skills they will need in later life. |
| Perceived student ability (PSA) | Teachers' beliefs about the capacity of students to engage in higher-order thinking. |
| Self-efficacy (SE) | Teachers' self-perceived capability to stimulate higher-order thinking in students. |
| Context dependency (CD) | Teachers' perceptions that external factors are a prerequisite for being able to stimulate higher-order thinking in students. |

Another important finding in both reviews was that hardly any studies explore the relationship between teachers' attitudes and their (intended) behaviour aimed at respectively using technology and stimulating students' higher-order thinking. Furthermore, in the context of technology use, Scherer et al. (2020) found insufficient evidence for the assumption that teachers' intention to use technology has a significant influence on teachers' actual use of technology. This is especially problematic because without insight into the relationship between teachers' attitude and teaching behaviour, we do not know which attitudinal factors are important to consider if we want to support teachers in their technology use and stimulation of students' higher-order thinking.

## Development and validation of the TANT questionnaire

In the context of technology use, many instruments exist that aim to measure teachers' attitudes towards using technology. However, there are several issues that have an impact on many of these instruments. One of these issues is that to gain insight into teachers' attitudes towards using *new* technology we would need an instrument that can be used to measure these attitudes. However, to our knowledge no such instrument exists. Therefore, we developed and evaluated the validity and reliability of an instrument that can be used to measure pre- and in-service primary school Teachers' Attitudes towards using New Technology in teaching and teachers' actual new technology use (the TANT questionnaire).

For the development of the TANT questionnaire (Chapter 3) we translated eight of the nine attitudinal factors that were identified in our literature review (see Table 1). We did not include 'perceived effect on student motivation' (PESM). This factor represents to what extent teachers believe that using technology in teaching

motivates students to learn. We assumed that teachers' perceptions regarding the effect of technology on students' motivation to learn could be considered an aspect of 'perceived usefulness' (PU). We therefore did not develop a separate set of items for 'perceived effect on student motivation' (PESM).
The results of our statistical analyses showed that the TANT questionnaire meets the requirements for reliability and construct validity for six factors. The items designed to measure the factors perceived ease of use and anxiety loaded together on one factor. We therefore combined these items to form a new scale which we named 'perceived difficulty' (PD). Furthermore, the scale 'enjoyment' was deleted due to poor results of the analyses on the items designed to measure this factor. The TANT questionnaire can be used to validly and reliably measure the factors perceived relevance, perceived usefulness, perceived difficulty, self-efficacy, context dependency, and subjective norms.

Furthermore, we found that the TANT questionnaire measures teachers' attitude towards using new technology similarly for both pre- and in-service teachers. Therefore, scores on the TANT questionnaire of pre- and in-service primary school teachers may be compared (Chen, 2007).

In addition to developing measures of attitude for the TANT questionnaire, we also developed a scale to measure teachers' actual use of new technology. These behavioural items reflected teachers' use of new technology, such as the use of new technology to let students present to each other what they learned or using new technology to connect learning inside school with learning outside school.

Our statistical analyses on the 'new technology use' scale showed that this scale meets the requirements for construct validity and reliability. These are important results, because this means that the 'new technology use' scale is a valid and reliable measure of new technology use.

After determining the validity and reliability of the TANT questionnaire, we analysed teachers' responses to the items. From these analyses we learned that, in line with other research, pre- and in-service primary school teachers regard it relevant to use new technology in their teaching to prepare students for their later life (e.g. González-Carriedo & Esprivalo Harrel, 2018; Magen-Nagar & Firstater, 2019), believed new technology is a beneficial tool for teaching (e.g., Leem & Sung, 2019; Zhang, 2019), and felt somewhat dependent on contextual factors such as training and technical support (Frazier et al., 2019; O'Neal et al., 2017). Furthermore, we found that teachers perceived the use of new technology in their teaching as somewhat difficult, had somewhat low feelings of self-efficacy, and felt that their social environment is neutral about the use of new technology in teaching.

Despite the average to high scores on the attitudinal factors, both pre- and in-service teachers indicated to make very little use of new technology. A possible explanation may be found in the relatively low scores on self-efficacy, which according to our analyses was the factor that explained the most variance in new technology use. The influence of self-efficacy on teachers' technology use is also confirmed in other studies (e.g., Jeong & Kim, 2017; Jung et al., 2019; Ottenbreit-Leftwich et al., 2018). These results seem to indicate that teachers' perceptions regarding their ability to use (new) technology impact their actual (new) technology use.

## Development and validation of the SHOT questionnaire

To our knowledge, no instrument exists that can be used to measure teachers' attitudes and/or actual behaviour in stimulating higher-order thinking in students. To address this, we developed and evaluated the validity and reliability of an instrument that can be used to measure pre- and in-service primary school teachers' attitudes towards Stimulating Higher-Order Thinking in students (the SHOT questionnaire). In addition, the SHOT questionnaire measures teachers' actual behaviour related to stimulating higher-order thinking in students.

For the development of the SHOT questionnaire (Chapter 4), we translated the four attitudinal factors that we identified in our literature review (See Table 2) into corresponding Likert-type measurement scales. In addition, we designed items that can be used to measure teachers' self-reported behaviour aimed at stimulating higher-order thinking. The initial version of the SHOT questionnaire consisted of 28 items. We then used multiple statistical analyses to evaluate the psychometric qualities of the SHOT questionnaire.

Results of these analyses showed that the SHOT items designed to measure the intended four attitudinal scales (see Table 2) meet the requirements for reliability and construct validity. The results also showed that the items designed to measure teachers' behaviour aimed at stimulating higher-order thinking pertained to two scales, which both proved valid and reliable. The first scale measures activities a teachers may undertake to stimulate students' higher-order thinking (e.g., design a lesson, teach a lesson, give assignments). The second scale measures to what extent teachers encourage students to engage in different complex thinking processes (e.g., problem solving, creating new products). These are important results, because to our knowledge there are no validated instruments that can be used to measure how often teachers stimulate higher-order thinking in students.

Further analyses showed that the SHOT questionnaire measures teachers' attitude and self-reported behaviour related to encouraging students' higher-order thinking similarly for both pre- and in-service teachers. Therefore, scores on the SHOT questionnaire of pre- and in-service primary school teachers may be compared (Chen, 2007).

After determining the validity and reliability of the SHOT questionnaire, we analysed teachers' responses to the items. From these analyses we learned that, in line with previous research (AlJaafil, & Şahin, 2019; Ketelhut et al., 2020; Tornero, 2017), both pre- and in-service primary school teachers think it is important to stimulate higher-order thinking in students but that most teachers do not feel very capable to stimulate higher-order thinking (e.g., Schulz & FitzPatrick, 2016). However, in contrast to other research (e.g., Zohar et al., 2001) we found that both pre- and in-service teachers mostly agree that higher-order thinking is also suitable for low-achieving students. These are valuable insights, because to our knowledge the attitudes of primary school teachers towards using higher-order thinking have never been measured before using a thoroughly validated instrument. These insights can help us understand why teachers may (not) engage in teaching practices that explicitly stimulate students' higher-order thinking.

## Identification of teacher profiles

Teachers may differ in their attitudes towards using new technology and stimulating students' higher-order thinking. The identification of teacher profiles can help us understand how different teachers view the use of new technology and stimulating higher-order thinking in students and to what extent this impacts their teaching. This can help us understand, whether, how, and why teachers use new technology and/or stimulate students' higher-order thinking. Furthermore, identification of such profiles could provide insight into the needs for teacher support for different groups of teachers, which may allow us to develop teacher-tailored professionalization that fit these needs. To explore whether different groups or 'profiles' of teachers based on their attitudes towards using new technology and higher-order thinking can be identified, we conducted a fourth study in which we aimed to answer two research questions: (R1) which teacher profiles can be identified, based on pre- and in-service primary school teachers' attitudes towards using new technology in teaching and towards stimulating higher-order thinking in students? and (R2) do pre- and in-service primary school teachers recognize the identified profiles? (Chapter 5)

To evaluate whether such profiles exist we conducted a cluster-analysis on the data that was collected with the TANT and SHOT questionnaire ($n$ = 659). The results of the cluster-analysis revealed three profiles based on teachers' attitudes towards using new technology and stimulating students' higher-order thinking. Teachers in profile 1 can be characterized as teachers with a positive attitude towards using new technology and towards stimulating higher-order thinking. However, despite their positive attitudes towards using new technology, teachers in profile 1 still make very little use of new technology in their teaching (approximately a few times a year). In addition, these teachers stimulate students' higher-order thinking significantly more often than teachers in the other profiles, with a main focus on encouraging students to engage in complex thinking (approximately a few times a month to once a week). Based on these results we assume that when teachers stimulate students' higher-order thinking, they predominantly do so with teaching materials or assignments that do not include new technology.

Teachers in profile 2 believe that new technology is important and that it is a useful tool to enrich their teaching. However, they think that it is difficult to use new technology, feel dependent upon context factors (such as technical support) and do not feel very capable in using new technology, which might explain their limited use of new technology (approximately a few times a year). Furthermore, these teachers believe that it is fairly important to stimulate higher-order thinking in students but are unsure whether this is suitable for low-achieving students and feel dependent upon context-factors (such as ready-made materials) to be able to stimulate students' higher-order thinking. These teachers engage in teaching activities aimed at stimulating higher-order thinking a bit less than once a month and encourage students to engage in complex thinking approximately a few times a month. Since these teachers make little use of new technology in their teaching, and only occasionally stimulate students' higher-order thinking, we suspect that these teachers rarely use new technology for stimulating higher-order thinking.

Teachers in profile 3, who were mostly pre-service teachers from the same teacher education college, can be characterized as teachers who have a neutral attitude towards using new technology in teaching and a negative attitude towards stimulating higher-order thinking. These pre-service teachers do not think that it is very important to stimulate higher-order thinking, do not feel capable in stimulating higher-order thinking, and rarely stimulate students' higher-order thinking (approximately a few times a year). Furthermore, they do not feel very encouraged by their colleagues and school principal of the internship school to use new technology. Based on the results regarding the limited use of new technology and stimulating higher-order thinking, we assume that these teachers very rarely use new technology for stimulating students' higher-order thinking. Results of additional follow-up focus group interviews showed that teachers found the identified profiles recognizable.

Overall, research shows that teachers make little use of new technology in their teaching and do not stimulate students' higher-order thinking often (Backfish et al., 2020; Fraillon et al., 2013; Voogt et al., 2016). The identification of these different profiles suggests that the reasons for the limited use of new technology and limited stimulation of students' higher-order thinking may be different for different groups of teachers. This means that different teachers may need different forms of support to help them use new technology and stimulate students' higher-order thinking.

## Answering the main research question

The research question that we aimed to answer in this dissertation is: What are pre- and in-service primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students? It is important to gain insight into pre- an in-service primary school teachers' attitudes towards using new technology and stimulating higher-order thinking in students, because a persons' attitude may impact a persons' intention to engage in certain behaviour, which may lead to (changes in) actual behaviour.

To answer the research question, we first set out to identify relevant attitudinal factors that make up pre- and in-service primary school teachers' attitudes towards using technology in teaching and towards stimulating higher-order thinking in students. Then we developed two instruments that allowed us to measure pre- and in-service primary school teachers' attitudes and behaviour related to using new technology (TANT) and stimulating students' higher-order thinking (SHOT). Last, we conducted a study in which we identified teacher profiles based on pre- and in-service primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students.

Based on the results of these studies we conclude that teachers have differing attitudes towards using new technology and stimulating students' higher-order thinking. This finding seems to suggest that different approaches are necessary to support teachers in their use of new technology to stimulate students' higher-order thinking.

In our fourth study (Chapter 5) we identified three teacher profiles. These profiles show that some teachers (profile 1 teachers) have a positive attitude towards using new technology and towards stimulating higher-order thinking. However, despite their positive attitudes, these teachers make little use of new technology in teaching. It therefore seems likely to assume that these teachers make little use of new technology to stimulate students' higher-order thinking.

However, most teachers in our sample (profile 2 teachers) believe that using new technology is important, but do not feel very competent in the use of new technology and feel dependent upon context factors (such as technical support) to be able to use new technology. Also, profile 2 teachers believe it is fairly important to stimulate students' higher-order thinking but are unsure whether higher-order thinking is suitable for low-achieving students and feel dependent upon context-factors (such as ready-made materials) to be able to stimulate higher-order thinking. Since these teachers make little use of new technology in their teaching, and only occasionally stimulate students' higher-order thinking, we suspect that these teachers rarely use new technology for stimulating higher-order thinking.

Furthermore, there are also (mostly) pre-service teachers (profile 3 teachers) with a neutral attitude towards using new technology but a negative attitude towards stimulating higher-order thinking in students. These teachers do not think that it is very important to stimulate higher-order thinking, do not feel capable in stimulating higher-order thinking, and rarely stimulate students' higher-order thinking (approximately a few times a year). Furthermore, they do not feel very encouraged by their colleagues and school principal at their internship schools to use new technology. We assume that these teachers very rarely use new technology for stimulating students' higher-order thinking. Interestingly, we found that teachers with such attitudes were almost all pre-service from one specific teacher education college. This seems to suggest that the educational program of these pre-service teachers might impact their attitudes.

## Reflections and suggestions for further research

### *Developing and evaluating tailored teacher professionalization*

In our fourth study (Chapter 5) we identified teacher profiles, and in addition, measured teachers actual use of new technology and behaviour aimed at stimulating students' higher-order thinking per profile. The findings of this study seem to suggest that different approaches for support for teachers from the different profiles is necessary. We hypothesize that for profile 1 teachers who have positive attitudes, attitude-focused professionalization may be less important. Instead, support for these teachers might be focused on acquiring knowledge and skills about *how* new technology can be used for stimulating students' higher-order thinking. This might be done by providing examples of new technology use for stimulating students' higher-order thinking or by letting them plan and execute lessons in which they use new technology to stimulate students' higher-order thinking.

Furthermore, we hypothesize that it is important to focus professionalization for profile 2 teachers on enhancing their self-efficacy in using new technology and lowering their feelings of dependency on context factors for both new technology use and stimulating students' higher-order thinking. This can be done by engaging these teachers in attitude-focused professionalization. In such professionalization the focus should be on increasing feelings of confidence and raising awareness about teachers own attitudes. For example, teachers might believe that using new technology is 'just hard' and 'I can't use it'. By explicitly paying attention to such perceptions by asking questions such as: 'why do you think you can't use it?' 'What does it mean if you can't?' 'What if you could?' 'Can you learn how to use it? 'What would you need for that?' teachers may become aware of and challenge their perceptions. Such strategies, along with allowing teachers to practice in a safe environment, receiving feedback from an expert on their use of new technology and stimulation of higher-order thinking and providing examples and materials that teachers can use and explore might help them develop more positive attitudes. In the context of science teaching, such attitude-focused professionalization has proven to be successful in increasing feelings of self-efficacy and lowering feelings of context-dependency (Van Aalderen-Smeets & Walma van der Molen, 2015) and might be useful in this context as well.

Teachers with profile 3 who are mostly pre-service teachers from one specific teacher education college are characterized by their neutral attitude towards using new technology but a negative attitude towards stimulating students' higher-order thinking. To support profile 3 teachers, it might be important to take the educational program into account.

Tondeur et al., (2012) identified 12 themes that need to be in place in teachers' educational program to prepare future teachers to use technology. Six of these themes are related to preparing pre-service teachers at the micro-level: (1) using teacher educators as role models, (2) letting students reflect on digital applications in teaching and learning processes, (3) learning how to use technology by design, (4) collaborating with peers, (5) scaffolding authentic knowledge experiences (6) providing ongoing feedback. In addition, four themes are related to the institutional level: (1) technology planning and leadership, (2) co-operation within and between institutions, (3) staff development, and (4) access to resources. These four institutional themes are regarded as conditions that should be in place at a teacher education institute to prepare pre-service teachers to use technology in education. Two more overarching themes (1) aligning theory and practice, and (2) systematic and systemic change efforts are regarded important at both the micro- and institutional level. In a follow-up study, Tondeur et al., (2018) found that when pre-service teachers perceive more of the occurrences of six of micro-level themes during their pre-service training, they report higher (perceived) competencies in using ICT for learning. These findings may indicate that a teacher education program and the actions of teacher educators can impact pre-service teachers' attitudes and/or use of technology in their teaching.

Although, we were unable to find studies that explore whether pre-service teachers' attitudes towards stimulating higher-order thinking might be impacted by the educational program and teacher educators, it seems reasonable to think that whether and how much attention is paid to stimulating higher-order thinking in an educational program and to what extent teacher educators encourage pre-service teachers to stimulate higher-order thinking in their students might impact their attitudes towards stimulating higher-order thinking.

It seems important to gain a better understanding about why the pre-service teachers from this specific teacher education college have a negative attitude towards stimulating higher-order thinking and whether and to what extent this might be related to the educational program these teachers follow. Support might be incorporated in the educational program and/or teacher educators might be supported in how to teach pre-service teachers about the use of new technology and stimulating higher-order thinking.

According to the Theory of Planned Behaviour, the development of more positive attitudes impacts a person's intention to engage in certain behaviour and this might in turn impact actual behaviour. Therefore, we assume that supporting teachers in the development of more positive attitudes towards using new technology and stimulating students' higher-order thinking can result in more use of new technology and stimulation of students' higher-order thinking. That would allow students to develop crucial skills that they will need throughout their lives.

*Identifying additional relevant attitudinal factors for SHOT*

In the literature review (Chapter 2) we concluded that the amount of research on teachers' attitudes towards stimulating higher-order thinking was limited. It is therefore possible that other attitudinal factors might also be relevant when exploring teachers' attitudes towards stimulating higher-order thinking in students. Based on the Theory of Planned Behaviour (Ajzen, 1991; 2001), we expect that such factors might include affective components (e.g., anxiety or enjoyment), teachers' views of the social norm regarding stimulating higher-order thinking (does a teacher believe that stimulating higher-order thinking is appreciated by important others, such as colleagues?), and teachers' perceived difficulty (does a teacher believe it is difficult or easy to engage students in higher-order thinking?). We have suggested possible items for these scales. The inclusion of these factors may explain more variance of attitudinal factors on the behavioural scales of the SHOT questionnaire.

*Teachers' use of new technology for stimulating students' higher-order thinking*

To gain insight into teachers' attitudes towards using new technology and stimulating students' higher-order thinking we developed the TANT and SHOT questionnaire. In these questionnaires we included behavioural scales to gain insight into how often teachers use new technology and how often teachers stimulate higher-order thinking in students. However, with these scales we cannot gain insight into how often teachers use new technology *for* stimulating higher-order thinking. To gain insight in this, the items from the behavioural scales of the TANT and SHOT questionnaire might be combined to develop a behavioural scale that measures how often teachers use new technology *for* stimulating students' higher-order thinking. For example, the items 'How often do you encourage your students to find more than one solution for a problem?' and 'How often do students use new technology to work on challenging problems (such as designing gymnastics gear) in your lessons?' may be combined into an new item: 'How often do you teach a lesson in which students use new technology to find more than one solution for a problem?'. Furthermore, another behavioural scale could be included that measures teachers' use of technologies common to them. This way, we could compare how often teachers use 'common' and 'new' technologies.

*Pre- and in-service primary school teachers*

In our studies, we viewed pre- and in-service primary school teachers as one group. However, in our study on the identification of teacher profiles (Chapter 5) we found that one profile consists almost completely of pre-service teachers from one teacher education college. This raises questions about the appropriateness of viewing pre- and in-service teachers as one group. Although we included only third- and fourth-year pre-service teachers in our study, who usually have some teaching experience due to internships, pre-service teachers generally have a lot less teaching experience than in-service teachers which can impact their use of technology in teaching (Backfisch et al., 2020). Furthermore, pre-service teachers might have somewhat different social norms since important others for these teachers might also include their teacher educators. It could be that pre- and in-service teachers view the use of technology similarly (as Teo, 2015 found), but more research is needed to explore possible differences between pre- and in-service teachers for both new technology use and stimulating students' higher-order thinking. The results of our measurement invariance analyses showed that the TANT and SHOT questionnaires can be used to compare pre- and in-service teachers' attitudes towards using new technology and stimulating higher-order thinking in students. Therefore, the TANT and SHOT questionnaires are suitable instruments to explore differences between pre- and in-service teachers' attitudes in future studies.

*Impact of the COVID-19 pandemic*

The data for the studies in this dissertation, were collected before and at the start of the COVID-19 pandemic. Due to this pandemic, many teachers had to switch from face-to-face to online teaching. This switch to online teaching may have impacted teachers' attitudes towards using new technology as well as stimulating students' higher-order thinking. To evaluate whether teachers' attitudes may have changed due to the consequences of the Covid-19 pandemic the TANT and SHOT questionnaire can be used to gain insight into teachers' attitudes in a post-Covid period.

## Practical implications

The research presented in this dissertation has several practical implications. First, the TANT and SHOT questionnaires can be used by teachers to gain insight in their own attitudes towards using new technology and stimulating higher-order thinking in students. This might help teachers become aware of their attitudes and this could be a first step in developing more positive attitudes. For example, if a teacher finds that his/her score on the factor self-efficacy of the TANT questionnaire is low, a teacher may more consciously think about why he/she feels uncertain about his/

her capability to use new technology and what could help him/her to feel more confident. To make it easier for teachers to use the TANT and SHOT questionnaire, we developed a digital tool that teachers provide with an explanation about their attitudes after completing the digital version of the questionnaires (TechYourFuture, 2021). Furthermore, by completing the two digital questionnaires a teacher may learn which of the identified profiles suits them best. In a practical guide (Wijnen, Rougoor, & Schutte, 2021) tips and suggestions for actions are given that are specifically tailored to the three identified teacher profiles to give teachers some guidelines of possible actions that they can undertake when they know which profiles suits them best. In addition, this practical guide describes the results of our studies in an accessible way. This guide contains tips, practice examples and example assignments that teachers may use to use new technology in their teaching to stimulate students' higher-order thinking. We hope that this guide can help teachers to use new technology in their teaching to stimulate students' higher-order thinking.

Based on the outcomes and experiences gained from these studies, we believe that teachers should become aware of the relevance, enjoyment and opportunities that arise when students engage in innovative and creative thinking and are able to use new technologies to immerse, share, improve, and create novel ideas and understanding. Then they are able to show students that school is not only about learning to read, write and memorize facts, but that real learning is about challenging yourself, exploring ideas and collaborate with different people and the technological tools that are available to achieve this.

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# English summary

In this dissertation, we present four studies in which we explore primary school teachers' attitudes towards using (new) technology and stimulating students' higher-order thinking in students. Higher-order thinking skills, such as creative thinking, critical thinking, and problem solving are regarded as crucial for students to develop (Conklin, 2012; Driana & Ernawati, 2019). By engaging students in higher-order thinking, students may actively construct knowledge and engage in meaningful learning (Anderson et al., 2001). Therefore, teachers are expected to stimulate students to engage in higher-order thinking, since it cannot be assumed that students will automatically become good thinkers (Elder, 2003; Schulz & Fitzpatrick, 2016). This means that teachers should offer assignments or questions that require students to engage in complex cognitive processes (e.g., analysing, evaluating, and creating) to find a solution, make a decision, prediction, judgement or product.

Research shows that technology can be used as a tool to support students' learning, including higher-order thinking (Backfish et al., 2020; Mayer, 2019). However, most teachers use technology mainly to stimulate *lower-order* thinking (De Aldama & Pozo, 2016; Ertmer et al., 2015; Voogt et al., 2016; Smeets, 2018). In addition, technologies such as augmented reality, virtual reality, and games have been found to support students' learning and advance their higher-order thinking, compared to teaching practices that do not include such technologies (Araiza-Alba et al., 2021; Chiang et al., 2014; Passig et al., 2016; Tangkui & Keong, 2020). However, technology that is new for some teachers might be common practice for others. We use the term *new technology* for technologies that are considered new for the teachers in our studies. In the Dutch context (where our studies were conducted) teachers do not often use the technologies mentioned above (Smeets, 2020; Voogt et al., 2016) and we therefore expect that most teachers have little experience with these technologies in their teaching. Using technologies such as virtual reality and games in teaching would therefore be *new* for many Dutch primary school teachers.

To support pre- and in-service primary school teachers in their use of new technology to stimulate higher-order thinking, it is important that we gain an understanding of teachers' *attitudes* towards using new technology *and* towards stimulating higher-order thinking. However, there is little research on pre- and in-service primary school teachers' attitudes towards stimulating higher-order thinking, and we know little about teachers' attitudes towards using *new* technology. Therefore, we conducted four studies, described in this dissertation, to fill this void in research. The main research question that we aimed to answer is: What are pre- and in-service primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students?

# Main findings of the studies

## Systematic literature reviews

For the first study of this dissertation (Chapter 2), we conducted two literature reviews to (1) identify factors that make up teachers' attitudes towards using technology and (2) to identify factors that make up teachers' attitudes towards stimulating higher-order thinking. Furthermore, we evaluated what is known about the relationship between the identified attitudinal factors and teachers' intended and/or actual technology use and teachers' intention and/or actual behaviour to engage students in higher-order thinking. This gave us insight into the factors that are important to consider if we want to study teachers' attitude towards using (new) technology and towards stimulating students' higher-order thinking. The identified factors are presented in Table 1 and Table 2.

**Table 1** Identified attitudinal factors that make up primary school teachers' attitudes towards using (new) technology in teaching

| Factor | Definition |
|---|---|
| Perceived usefulness (PU) | Teachers' beliefs about the usefulness of technology for improving and/or enriching their teaching and the learning of their students. |
| Perceived ease of use (PEU) | Teachers' beliefs about the ease or difficulty of using technology in their teaching. |
| Perceived relevance (PR) | Teachers' beliefs about the importance of using technology in their teaching in order to prepare students for later life. |
| Perceived effect on student motivation (PESM) | Teachers' beliefs that using technology in teaching motivates students to learn and engages students in learning. |
| Anxiety (AX) | Negative feelings such as anxiety or fear when using technology. |
| Enjoyment (EY) | Positive feelings such as enjoyment or enthusiasm when using technology. |
| Self-efficacy (SE) | Teachers' self-perceived capability to use technology in their teaching. |
| Context dependency (CD) | Teachers' perceptions that external factors, (i.e., availability of resources, support, available time) are a prerequisite for them to be able to use technology. |
| Subjective norms (SN) | Teachers' perceptions as to whether other people who are important to that teacher think it is good or bad to use technology in teaching. |

**Table 2** Identified attitudinal factors that make up primary school teachers' attitudes towards stimulating higher-order thinking in students

| Factor | Definition |
|---|---|
| Perceived relevance (PR) | Teachers' belief about the importance of stimulating higher-order thinking in students in order to help them develop the necessary skills they will need in later life. |
| Perceived student ability (PSA) | Teachers' beliefs about the capacity of students to engage in higher-order thinking. |
| Self-efficacy (SE) | Teachers' self-perceived capability to stimulate higher-order thinking in students. |
| Context dependency (CD) | Teachers' perception that external factors are a prerequisite for being able to stimulate higher-order thinking in students. |

Another important finding in both reviews was that hardly any studies explore the relationship between teachers' attitudes and their (intended) behaviour aimed at respectively using technology and stimulating students' higher-order thinking. This is especially problematic because without insight into the relationship between teachers' attitude and teaching behaviour, we do not know which attitudinal factors are important to consider if we want to support teachers in their technology use and in their stimulation of students' higher-order thinking.

### *Development and validation of the TANT questionnaire*

To gain insight into pre- and in-service primary school teachers towards using new technology, we need to be able to measure these attitudes. However, to our knowledge, no instruments exist that can be used to measure teachers' attitudes towards using *new* technology. Therefore, we developed a new instrument that allows us to measure pre- and in-service primary school Teachers' Attitudes towards using New Technology (TANT questionnaire; Chapter 3). For the development of the TANT questionnaire (Chapter 3) we translated the attitudinal factors that were identified in our literature review (see Table 1). In addition to measures of attitude, we also included items to measure teachers self-reported use of new technology. We distributed the TANT questionnaire among a large sample of pre- and in-service primary school teachers ($n = 659$). We then used multiple statistical analyses to evaluate the psychometric qualities of the TANT questionnaire.

Results of these analyses showed that the TANT questionnaire can be used to measure six attitudinal factors validly and reliably. The items designed to measure the factors perceived ease of use and anxiety loaded together on one factor. We therefore combined these items to form a new scale which we named 'perceived difficulty'. Furthermore, the scale 'enjoyment' was deleted due to poor results of the analyses on the items designed to measure this factor. The TANT questionnaire can be used to validly and reliably measure the factors perceived relevance, perceived usefulness, perceived difficulty, self-efficacy, context dependency, and subjective norms.

Furthermore, the items designed to measure teachers use of new technology proved valid and reliable. In addition, we found that the TANT questionnaire measures the attitudinal factors similarly for both pre- and in-service teachers. Therefore, scores on the TANT questionnaire of pre- and in-service primary school teachers may be compared.

After determining the validity and reliability of the TANT questionnaire, we analysed teachers' responses to the items. From these analyses we learned that pre- and in-service primary school teachers regard it relevant to use new technology in their teaching to prepare students for their later life, believed new technology is a beneficial tool for teaching, and felt somewhat dependent upon contextual factors such as training and technical support. Furthermore, we found that teachers perceived the use of new technology in their teaching as somewhat difficult, had somewhat low feelings of self-efficacy, and felt that their social environment is neutral about the use of new technology in teaching.

Furthermore, we found that both pre- and in-service teachers indicated to make very little use of new technology. A possible explanation may be found in the relatively low scores on self-efficacy, which according to our analyses was the factor that explained the most variance in new technology use. These results seem to indicate that teachers' perceptions regarding their ability to use new technology impact their actual new technology use.

*Development and validation of the SHOT questionnaire*

To our knowledge no instrument exists for measuring teachers' attitudes towards stimulating students' higher-order thinking. Therefore, we set out to develop a new instrument to measure pre- and in-service primary school teachers' attitudes towards Stimulating Higher-Order Thinking in students (SHOT questionnaire; Chapter 4). For the development of the SHOT questionnaire, we translated the four attitudinal factors that we identified in our literature review into scales consisting of several items. In addition, we also included items to measure teachers self-reported behaviour in stimulating students' higher-order thinking. We distributed the SHOT questionnaire simultaneously with the TANT questionnaire among the same sample of pre- and in-service primary school teachers ($n$ = 659) as was used for the TANT questionnaire.

The results of the analyses of the SHOT questionnaire showed that this questionnaire can be used to measure the four attitudinal factors (see Table 2) in a valid and reliable way. Furthermore, the items designed to measure teachers' behaviour aimed at stimulating students' higher-order thinking can be used to measure two types of behaviour, namely: teacher activities which reflects different activities a teacher can undertake to stimulate higher-order thinking (e.g., design a lesson, teach a lesson, give assignments), and encouraging students, which reflects teaching behaviour aimed encouraging students to engage in different complex thinking processes (e.g., problem solving, creating new products). In addition, we found that the scores on the SHOT questionnaire of pre- and in-service primary school teachers may be compared because both groups interpret the questionnaire similarly. This means that the SHOT questionnaire could be used to explore differences in pre- and in-service primary school teachers' attitudes towards stimulating higher-order thinking in students.

After determining the validity and reliability of the SHOT questionnaire, we analysed the responses on the SHOT questionnaire. The results of these analyses show that pre- and in-service teachers believe stimulating higher-order thinking is relevant to support students in their development, believe that higher-order thinking is appropriate for low-achieving students, feel moderately capable in stimulating higher order thinking, and feel moderately dependent on context-factors. Furthermore, both pre- and in-service teachers engage in teaching activities aimed at stimulating higher-order thinking a bit more often than a few times a year and encourage students in higher-order thinking a bit more often than once a month.

*Identification of teacher profiles*

In our last study (Chapter 5) we combined measures of teachers' attitude towards using new technology and towards stimulating higher-order thinking to identify teacher profiles based on these attitudes. This might help us understand, whether, how and why teachers use new technology and/or stimulate students' higher-order thinking. Furthermore, identification of such profiles could provide insight in the needs for teacher support for different groups of teachers, which may allow us to develop teacher-tailored professionalization that fit these needs.

To evaluate whether such profiles exist we conducted a cluster-analysis on the data that was collected with the TANT and SHOT questionnaire ($n$ = 659). The results of the cluster-analysis revealed three profiles based on teachers' attitudes towards using new technology and stimulating students' higher-order thinking. Teachers in profile 1 can be characterized as teachers with a positive attitude towards using new technology and towards stimulating higher-order thinking. However, despite their positive attitudes towards using new technology, teachers in profile 1 still make very little use of new technology in their teaching (approximately a few times a year). In addition, these teachers stimulate students' higher-order thinking significantly more often than teachers in the other profiles, with a main focus on encouraging students to engage in complex thinking (approximately a few times a month to once a week). Based on these results we assume that when teachers stimulate students' higher-order thinking, they predominantly do so with teaching materials or assignments that do not include new technology.

Teachers in profile 2 believe that new technology is important and that it is a useful tool to enrich their teaching. However, they think that it is difficult to use new technology, feel dependent upon context factors (such as technical support) and do not feel very capable in using new technology, which might explain their limited use of new technology (approximately a few times a year). Furthermore, these teachers believe that it is fairly important to stimulate higher-order thinking in students but are unsure whether this is suitable for low-achieving students and feel dependent upon context-factors (such as ready-made materials) to be able to stimulate higher-order thinking. These teachers engage in teaching activities aimed at stimulating higher-order thinking a bit less than once a month and encourage students to engage in complex thinking approximately a few times a month. Since these teachers make little use of new technology in their teaching, and only occasionally stimulate students' higher-order thinking, we assume that these teachers rarely use new technology for stimulating higher-order thinking.

Teachers in profile 3, who were mostly pre-service teachers from the same teacher education college, can be characterized as teachers who have a neutral attitude towards using new technology in teaching and a negative attitude towards stimulating higher-order thinking. These teachers do not think that it is very important to stimulate higher-order thinking, do not feel capable in stimulating higher-order thinking, and rarely stimulate students' higher-order thinking (approximately a few times a year). Furthermore, they do not feel very encouraged by their colleagues and school director to use new technology. Based on the results regarding the limited use of new technology and stimulating higher-order thinking, we assume that these teachers very rarely use new technology for stimulating students' higher-order thinking. Results of additional follow-up focus group interviews showed that teachers found the identified profiles recognizable. The identification of these different profiles suggests that the reasons for the limited use of new technology and limited stimulation of students' higher-order thinking may be different for different groups of teachers. This means that different teachers may need different forms of support to help them use new technology to stimulate students' higher-order thinking.

## Conclusions

The research question that we aimed to answer in this dissertation is: What are pre- and in-service primary school teachers' attitudes towards using new technology in teaching and stimulating higher-order thinking in students? Based on the results of the four studies we conclude that teachers have differing attitudes towards using new technology and stimulating students' higher-order thinking. This finding seems to suggest that different approaches are necessary to support teachers in their use of new technology to stimulate students' higher-order thinking.

In our fourth study (Chapter 5) we identified three teacher profiles. These profiles show that some teachers (profile 1 teachers) have a positive attitude towards using new technology and towards stimulating higher-order thinking. We hypothesize that for these teachers, support might be focused on acquiring knowledge and skills about *how* new technology can be used for stimulating students' higher-order thinking. This might be done by providing examples of new technology use for stimulating students' higher-order thinking or by letting them plan and execute lessons in which they use new technology to stimulate students' higher-order thinking.

However, most teachers in our sample are profile 2 teachers. They believe that using new technology is important, but do not feel very competent in the use of new technology and feel dependent upon context factors (such as technical support) to be able to use new technology. Also, these teachers believe it is fairly important to stimulate students' higher-order thinking but are unsure whether higher-order thinking is suitable for low-achieving students and feel dependent upon context-factors (such as ready-made materials) to be able to stimulate higher-order thinking.

Based on these findings we hypothesize that for profile 2 teachers it is important to focus support on enhancing their self-efficacy and lowering their feelings of dependency on context factors. This might be done by engaging these teachers in attitude-focused professionalization. In such professionalization the focus might be on increasing feelings of confidence and raising awareness about teachers own attitudes

Furthermore, there are also (mostly pre-service) teachers with a neutral attitude towards using new technology but a negative attitude towards stimulating higher-order thinking in students (profile 3). Interestingly, we found that teachers with such attitudes were almost all pre-service teachers from one specific teacher education college. Therefore, to support these pre-service teachers, it might be important to take the educational program into account.

Based on the outcomes and experiences gained from these studies, we believe that teachers should become aware of the relevance, enjoyment and opportunities that arise when students engage in innovative and creative thinking and are able to use new technologies to immerse, share, improve, and create novel ideas and understanding. Then they are able to show students that school is not only about learning to read, write and memorize facts, but that real learning is about challenging yourself, exploring ideas and collaborate with different people and the technological tools that are available to achieve this.

# Nederlandse samenvatting *(Dutch summary)*

In dit proefschrift presenteren we vier studies waarin we de houding van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van (nieuwe) technologie en het stimuleren van hogere-orde denken bij leerlingen onderzoeken. Hogere-orde denkvaardigheden, zoals creatief denken, kritisch denken en probleemoplossend denken, worden als cruciaal beschouwd voor leerlingen om te ontwikkelen (Conklin, 2012; Driana & Ernawati, 2019). Door leerlingen aan te moedigen om hogere-orde te denken, kunnen leerlingen actief kennis construeren en zich bezighouden met betekenisvol leren (Anderson et al., 2001). Van leerkrachten wordt daarom verwacht dat zij leerlingen stimuleren om zich bezig te houden met hogere-orde denken, aangezien er niet vanuit kan worden gegaan dat leerlingen vanzelf goede denkers worden (Elder, 2003; Schulz & Fitzpatrick, 2016). Dit betekent dat leerkrachten opdrachten of vragen moeten aanbieden waarbij leerlingen complexe cognitieve processen moeten toepassen (bijvoorbeeld analyseren, evalueren en creëren) om een oplossing te vinden, een beslissing te nemen, een voorspelling te doen, een oordeel te vellen of een product te maken.

Uit onderzoek blijkt dat technologie kan worden ingezet als hulpmiddel om het leren van leerlingen te ondersteunen, ook het hogere-orde denken (Backfish et al., 2020; Mayer, 2019). De meeste leerkrachten gebruiken technologie echter vooral om lagere-orde-denken te stimuleren (De Aldama & Pozo, 2016; Ertmer et al., 2015; Voogt et al., 2016; Smeets, 2018). Uit onderzoek blijkt dat technologieën zoals augmented reality, virtual reality en games het leren van leerlingen ondersteunen en hun hogere-orde denken bevorderen, in vergelijking met onderwijspraktijken waarin dergelijke technologieën niet gebruikt worden (Araiza-Alba et al., 2021; Chiang et al., 2014; Passig et al., 2016; Tangkui & Keong, 2020). Technologie die voor sommige leerkrachten nieuw is, kan voor anderen echter gebruikelijk zijn. We gebruiken de term *nieuwe technologie* voor technologieën die voor leerkrachten als nieuw worden beschouwd in onze studies. In de Nederlandse context (waar onze studies zijn uitgevoerd) maken leerkrachten niet vaak gebruik van de bovengenoemde technologieën (Smeets, 2020; Voogt et al., 2016) en we verwachten daarom dat de meeste leerkrachten weinig ervaring hebben met deze technologieën in hun onderwijs. Het gebruik van technologieën zoals virtual reality en games in het onderwijs zou voor veel Nederlandse basisschoolleerkrachten dan ook nieuw zijn.

Om basisschoolleerkrachten te ondersteunen in hun gebruik van nieuwe technologie om hogere-orde denken te stimuleren, is het belangrijk dat we inzicht krijgen in de attitudes van leerkrachten ten opzichte van het gebruik van nieuwe technologie *en* ten opzichte van het stimuleren van hogere-orde denken. Er is echter weinig onderzoek gedaan naar de attitudes van leerkrachten in het basisonderwijs ten opzichte van het stimuleren van hogere-orde denken, en we weten weinig over de attitudes van leerkrachten ten opzichte van het gebruik van *nieuwe* technologie. Daarom hebben we vier studies uitgevoerd, beschreven in dit proefschrift, om deze leemte op te vullen. De belangrijkste onderzoeksvraag die we wilden beantwoorden is: Wat zijn de attitudes van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van nieuwe technologie in het onderwijs en het stimuleren van hogere-orde denken bij leerlingen?

## Belangrijkste bevindingen van de studies

### Systematisch literatuuronderzoek

Voor de eerste studie van dit proefschrift (Hoofdstuk 2) hebben we twee literatuurstudies uitgevoerd om (1) factoren te identificeren die de attitudes van leerkrachten ten aanzien van het gebruik van technologie vormen en (2) om factoren te identificeren die de attitudes van leerkrachten ten aanzien van het stimuleren van hogere-orde denken vormen. Verder evalueerden we wat er bekend is over de relatie tussen de geïdentificeerde attitudefactoren en het bedoelde en/of werkelijke technologiegebruik van leerkrachten en het bedoelde en/of werkelijke gedrag van leerkrachten om leerlingen te stimuleren om hogere-orde te denken. Deze literatuurstudies gaven ons inzicht in factoren die belangrijk zijn om te overwegen als we de houding van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van (nieuwe) technologie en ten opzichte van het stimuleren van het hogere-orde denken van leerlingen willen bestuderen. De geïdentificeerde factoren zijn weergegeven in Tabel 1 en Tabel 2.

Een andere belangrijke bevinding in beide reviews was dat de relatie tussen de attitudes van leerkrachten en hun (voorgenomen) gedrag gericht op respectievelijk het gebruik van technologie en het stimuleren van het hogere-orde denken van leerlingen nauwelijks is onderzocht. Dit is vooral problematisch omdat we zonder inzicht in de relatie tussen attitude en onderwijsgedrag niet weten welke attitudefactoren van belang zijn als we leerkrachten willen ondersteunen bij hun technologiegebruik en bij hun stimulering van het hogere-orde denken van leerlingen.

### *Ontwikkeling en validatie van de TANT-vragenlijst*

Om inzicht te krijgen in de houding van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van nieuwe technologie, moeten we in staat zijn om deze houdingen te meten. Voor zover wij weten bestaan er echter geen instrumenten die gebruikt kunnen worden om de attitudes van leerkrachten ten opzichte van het gebruik van *nieuwe* technologie te meten. Daarom hebben we een nieuw instrument ontwikkeld dat ons in staat stelt om de attitudes van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van

**Tabel 1** Geïdentificeerde attitude factoren die de houding van leerkrachten in het basisonderwijs vormen ten opzichte van het gebruik van (nieuwe) technologie in het onderwijs

| Factor | Definitie |
|---|---|
| Waargenomen nut | Overtuigingen van leerkrachten over het nut van technologie voor het verbeteren en/of verrijken van hun onderwijs en het leren van hun leerlingen. |
| Waargenomen gebruiksgemak | Overtuigingen van leerkrachten over het gemak of de moeilijkheid van het gebruik van technologie in hun onderwijs. |
| Waargenomen relevantie | De mening van leerkrachten over het belang van het gebruik van technologie in hun onderwijs om de leerlingen voor te bereiden op het latere leven. |
| Waargenomen effect op de motivatie van de leerlingen | De overtuiging van de leerkrachten dat het gebruik van technologie in het onderwijs de leerlingen motiveert om te leren en hen bij het leren betrekt. |
| Vrees | Negatieve gevoelens zoals bezorgdheid of angst bij het gebruik van technologie. |
| Plezier | Positieve gevoelens zoals plezier of enthousiasme bij het gebruik van technologie. |
| Zelf-ingeschatte bekwaamheid | De door leerkrachten zelf ingeschatte bekwaamheid om technologie in hun lessen te gebruiken. |
| Contextafhankelijkheid | De perceptie van leerkrachten dat externe factoren (bv. beschikbaarheid van middelen, ondersteuning, beschikbare tijd) een voorwaarde zijn om technologie te kunnen gebruiken. |
| Subjectieve normen | De perceptie van een leerkracht dat andere mensen die belangrijk zijn voor die leerkracht, het goed of slecht vinden om technologie te gebruiken in het onderwijs. |

nieuwe technologie te meten (TANT-vragenlijst; Hoofdstuk 3). Voor de ontwikkeling van de TANT-vragenlijst (Hoofdstuk 3) hebben we de attitude factoren die in onze literatuurstudie zijn geïdentificeerd vertaald naar items (zie Tabel 1). Naast attitude-metingen hebben we ook items opgenomen om het zelf gerapporteerde gebruik van nieuwe technologie door leerkrachten te meten. We verspreidden de TANT-vragenlijst onder een grote steekproef van leerkrachten in het basisonderwijs (n = 659). Vervolgens gebruikten we meerdere statistische analyses om de psychometrische kwaliteiten van de TANT-vragenlijst te evalueren.

De resultaten van deze analyses toonden aan dat de TANT-vragenlijst kan worden gebruikt om zes attitudefactoren valide en betrouwbaar te meten. De items die ontworpen waren om de factoren 'waargenomen gebruiksgemak' en 'vrees' te meten, laadden samen op één factor. Daarom combineerden we deze items tot

**Tabel 2** Geïdentificeerde attitude factoren die de houding van leerkrachten in het basisonderwijs vormen ten opzichte van het stimuleren van hogere-orde denken bij leerlingen.

| Factor | Definitie |
|---|---|
| Waargenomen relevantie | De overtuiging van leerkrachten over het belang van het stimuleren van hogere-orde denken bij leerlingen om hen te helpen de nodige vaardigheden te ontwikkelen die zij in het latere leven nodig zullen hebben. |
| Waargenomen bekwaamheid van de student | De overtuiging van leerkrachten over de capaciteit van de leerlingen om aan hogere-orde denken te doen. |
| Zelf-ingeschatte bekwaamheid | De door de leerkracht zelf ingeschatte bekwaamheid om hogere-orde denken bij leerlingen te stimuleren. |
| Contextafhankelijkheid | De perceptie van leerkrachten dat externe factoren een voorwaarde zijn om het hogere-orde denken bij leerlingen te kunnen stimuleren. |

een nieuwe schaal die we 'waargenomen moeilijkheid' noemden. Verder werd de schaal 'plezier' geschrapt wegens slechte resultaten van de analyses op de items die ontworpen waren om deze factor te meten. De TANT-vragenlijst kan gebruikt worden om de factoren waargenomen relevantie, waargenomen nut, waargenomen moeilijkheid, zelf-ingeschatte bekwaamheid, contextafhankelijkheid, en subjectieve normen op een valide en betrouwbare manier te meten.

Daarnaast bleken de items die ontworpen waren om het gebruik van nieuwe technologie door leerkrachten te meten, valide en betrouwbaar. Bovendien vonden we dat de TANT-vragenlijst de attitudefactoren op vergelijkbare wijze meet voor zowel aanstaande als zittende basisschoolleerkrachten. Daarom kunnen scores op de TANT-vragenlijst van zittende leerkrachten en leerkrachten in opleiding met elkaar worden vergeleken.

Nadat we de validiteit en betrouwbaarheid van de TANT-vragenlijst hadden vastgesteld, analyseerden we de antwoorden van de leerkrachten op de items. Uit deze analyses bleek dat leerkrachten in het basisonderwijs het relevant vinden om nieuwe technologie te gebruiken in hun lessen om leerlingen voor te bereiden op hun latere leven, geloofden dat nieuwe technologie een nuttig instrument is voor het lesgeven, en zich enigszins afhankelijk voelden van contextuele factoren zoals training en technische ondersteuning. Verder vonden we dat leerkrachten het gebruik van nieuwe technologie in hun onderwijs als enigszins moeilijk ervaarden, een enigszins laag gevoel van zelf-bekwaamheid hadden, en vonden dat hun sociale omgeving neutraal stond tegenover het gebruik van nieuwe technologie in het onderwijs.

Ook vonden we dat zowel aanstaande als zittende leerkrachten aangaven zeer weinig gebruik te maken van nieuwe technologie. Een mogelijke verklaring kan gevonden worden in de relatief lage scores op zelf-ingeschatte bekwaamheid, die volgens onze analyses de factor was die de meeste variantie in het gebruik van nieuwe technologie verklaarde. Deze resultaten lijken erop te wijzen dat de percepties van leerkrachten over hun bekwaamheid in het gebruik van nieuwe technologie van invloed zijn op hun feitelijk gebruik van nieuwe technologie.

*Ontwikkeling en validatie van de SHOT-vragenlijst*

Voor zover wij weten, bestaan er geen instrumenten om de attitudes van leerkrachten ten aanzien van het stimuleren van het hogere-orde denken bij leerlingen te meten. Daarom hebben we een nieuw instrument ontwikkeld om deze attitudes van aanstaande en zittende basisschoolleerkrachten te kunnen meten (de SHOT-vragenlijst; Hoofdstuk 4). Voor de ontwikkeling van de SHOT-vragenlijst hebben we de vier attitudefactoren die we in onze literatuurstudie hadden geïdentificeerd (zie Tabel 2), vertaald naar schalen die uit verschillende items bestonden. Daarnaast hebben we ook items opgenomen om het zelf gerapporteerde gedrag van leerkrachten te meten bij het stimuleren van het hogere-orde denken van leerlingen. We verspreidden de SHOT-vragenlijst gelijktijdig met de TANT-vragenlijst onder dezelfde steekproef van leerkrachten in het basisonderwijs (n = 659) die voor de TANT-vragenlijst werd gebruikt.

De resultaten van de analyses van de SHOT-vragenlijst toonden aan dat deze vragenlijst kan worden gebruikt om de vier attitudefactoren op een valide en betrouwbare manier te meten. Bovendien kunnen de items die ontworpen zijn om het gedrag van leerkrachten te meten dat erop gericht is het hogere-orde denken van leerlingen te stimuleren, gebruikt worden om twee soorten gedrag te meten, namelijk: (1) leerkrachtactiviteiten, die verschillende activiteiten weerspiegelen die een leerkracht kan ondernemen om het hogere-orde denken te stimuleren (bv. een les ontwerpen, een les geven, opdrachten geven), en (2) het aanmoedigen van leerlingen, dat leerkrachtgedrag weerspiegelt dat erop gericht is leerlingen aan te moedigen om verschillende complexe denkprocessen aan te gaan (bv. problemen oplossen, nieuwe producten creëren). Verder vonden we dat de scores op de SHOT-vragenlijst van aanstaande en zittende basisschoolleerkrachten met elkaar vergeleken kunnen worden omdat beide groepen de vragenlijst op dezelfde manier interpreteren. Dit betekent dat de SHOT-vragenlijst gebruikt kan worden om verschillen te onderzoeken in de houding van aanstaande en zittende leerkrachten ten opzichte van het stimuleren van hogere-orde denken bij leerlingen.

Nadat de validiteit en betrouwbaarheid van de SHOT-vragenlijst waren vastgesteld, analyseerden we de antwoorden op de SHOT-vragenlijst. De resultaten van deze analyses laten zien dat aanstaande en zittende basisschoolleerkrachten denken dat het stimuleren van hoger(E) orde denken relevant is om leerlingen te ondersteunen in hun ontwikkeling, denken dat hogere-orde denken geschikt is voor 'zwakke' leerlingen, zich matig bekwaam voelen in het stimuleren van hogere-orde denken, en zich matig afhankelijk voelen van context-factoren. Verder ondernemen zowel zittende als aanstaande leerkrachten iets vaker dan een paar keer per jaar onderwijsactiviteiten gericht op het stimuleren van hogere-orde denken en stimuleren ze leerlingen iets vaker dan eens per maand in hogere-orde denken.

*Identificatie van leerkrachtprofielen*

In onze laatste studie (Hoofdstuk 5) combineerden we metingen van de attitudes van leerkrachten ten aanzien van het gebruik van nieuwe technologie en ten aanzien van het stimuleren van hogere-orde denken om leerkrachtprofielen te identificeren op basis van deze attitudes. De identificatie van deze profielen zou ons kunnen helpen te begrijpen of, hoe en waarom leerkrachten nieuwe technologie gebruiken en/of het hogere-orde denken van leerlingen stimuleren. Bovendien zou de identificatie van dergelijke profielen inzicht kunnen verschaffen in de behoeften aan ondersteuning voor verschillende groepen leerkrachten, wat ons in staat zou kunnen stellen om afgestemde professionalisering te ontwikkelen die aan deze behoeften beantwoordt.

Om na te gaan of dergelijke profielen bestaan, voerden we een clusteranalyse uit op de gegevens die verzameld werden met de TANT en SHOT vragenlijst (n = 659). De resultaten van de cluster-analyse brachten drie profielen aan het licht, gebaseerd op de attitudes van leerkrachten ten opzichte van het gebruik van nieuwe technologie en het stimuleren van het hogere-orde denken van leerlingen. Leerkrachten in profiel 1 kunnen worden gekarakteriseerd als leerkrachten met een positieve houding ten opzichte van het gebruik van nieuwe technologie en ten opzichte van het stimuleren van hogere-orde denken. Echter, ondanks hun positieve houding ten aanzien van het gebruik van nieuwe technologie, maken leerkrachten in profiel 1 nog weinig gebruik van nieuwe technologie in hun onderwijs (ongeveer een paar keer per jaar). Daarnaast stimuleren deze leerkrachten significant vaker dan leerkrachten in de andere profielen het hogere-orde denken van leerlingen, waarbij de nadruk vooral ligt op het stimuleren van leerlingen om complex te denken (ongeveer een paar keer per maand tot een keer per week). Op basis van deze resultaten veronderstellen we dat wanneer leerkrachten het hogere-orde denken van leerlingen stimuleren, zij dit voornamelijk doen met lesmateriaal of opdrachten waarin geen nieuwe technologie is verwerkt.

Leerkrachten in profiel 2 zijn van mening dat nieuwe technologie belangrijk is en dat het een nuttig instrument is om hun onderwijs te verrijken. Zij vinden het echter moeilijk om nieuwe technologie te gebruiken, voelen zich afhankelijk van contextfactoren (zoals technische ondersteuning) en voelen zich niet erg bekwaam in het gebruik van nieuwe technologie, wat hun beperkte gebruik van nieuwe technologie (ongeveer een paar keer per jaar) zou kunnen verklaren. Verder zijn deze leerkrachten van mening dat het redelijk belangrijk is om het hogere-orde denken bij leerlingen te stimuleren, maar ze weten niet zeker of dit geschikt is voor 'zwakke' leerlingen en voelen zich afhankelijk van contextfactoren (zoals kant-en-klare materialen) om het hogere-orde denken te kunnen stimuleren. Deze leerkrachten ondernemen iets minder dan één keer per maand onderwijs-activiteiten gericht op het stimuleren van hogere-orde denken en stimuleren leerlingen ongeveer een paar keer per maand tot complex denken. Aangezien deze leerkrachten weinig gebruik maken van nieuwe technologie in hun onderwijs en slechts af en toe het hogere-orde denken van leerlingen stimuleren, nemen we aan dat deze leerkrachten zelden gebruik maken van nieuwe technologie voor het stimuleren van hogere-orde denken.

Leerkrachten in profiel 3, meestal aanstaande leerkrachten van dezelfde lerarenopleiding, kunnen gekarakteriseerd worden als leerkrachten die een neutrale houding hebben ten opzichte van het gebruik van nieuwe technologie in het onderwijs en een negatieve houding ten opzichte van het stimuleren van hogere-orde denken. Deze leerkrachten vinden het niet erg belangrijk om hogere-orde denken te stimuleren, voelen zich weinig bekwaam in het stimuleren van hogere-orde denken bij leerlingen en stimuleren het hogere-orde denken van leerlingen maar zelden (ongeveer een paar keer per jaar). Bovendien voelen zij zich door hun collega's en de schooldirecteur niet erg aangemoedigd om nieuwe technologie te gebruiken. Op basis van de resultaten met betrekking tot het beperkte gebruik van nieuwe technologie en het stimuleren van hogere-orde denken, veronderstellen we dat deze leerkrachten zeer zelden nieuwe technologie gebruiken om het hogere-orde denken van leerlingen te stimuleren. Uit de resultaten van uitgevoerde follow-up focusgroep interviews bleek dat leerkrachten de geïdentificeerde profielen herkenbaar vonden. De identificatie van deze verschillende profielen suggereert dat de redenen voor het beperkte gebruik van nieuwe technologie en beperkte stimulatie van het hogere-orde denken bij leerlingen verschillend kunnen zijn voor verschillende groepen leerkrachten. Dit betekent dat verschillende leerkrachten verschillende vormen van ondersteuning nodig kunnen hebben om hen te helpen nieuwe technologie te gebruiken en het hogere-orde denken van leerlingen te stimuleren.

### *Conclusies*

De onderzoeksvraag die we in dit proefschrift wilden beantwoorden is: Wat zijn de attitudes van aanstaande en zittende basisschoolleerkrachten ten opzichte van het gebruik van nieuwe technologie in het onderwijs en het stimuleren van hogere-orde denken bij leerlingen? Op basis van de resultaten van de vier studies concluderen we dat leerkrachten verschillende attitudes hebben ten opzichte van het gebruik van nieuwe technologie en het stimuleren van hogere-orde denken bij leerlingen. Deze bevinding lijkt erop te wijzen dat verschillende benaderingen nodig zijn om leerkrachten te ondersteunen in hun gebruik van nieuwe technologie om het hogere-orde denken van leerlingen te stimuleren.

In onze vierde studie (hoofdstuk 5) identificeerden we drie leerkrachtprofielen. Deze profielen laten zien dat sommige leerkrachten (profiel 1 leerkrachten) een positieve houding hebben ten opzichte van het gebruik van nieuwe technologie en ten opzichte van het stimuleren van hogere-orde denken. We hypothetiseren dat voor deze leerkrachten de ondersteuning gericht zou kunnen zijn op het verwerven van kennis en vaardigheden over hoe nieuwe technologie gebruikt kan worden voor het stimuleren van het hogere-orde denken van leerlingen. Dit zou gedaan kunnen worden door voorbeelden te geven van het gebruik van nieuwe technologie voor het stimuleren van het hogere-orde denken van leerlingen of door hen lessen te laten plannen en uitvoeren waarin ze nieuwe technologie gebruiken om het hogere-orde denken van leerlingen te stimuleren.

De meeste leerkrachten in onze steekproef zijn echter profiel 2 leerkrachten. Zij vinden het gebruik van nieuwe technologie belangrijk, maar voelen zich niet erg competent in het gebruik van nieuwe technologie en voelen zich afhankelijk van contextfactoren (zoals technische ondersteuning) om nieuwe technologie te kunnen gebruiken. Ook vinden deze leerkrachten het tamelijk belangrijk om het hogere-orde denken van leerlingen te stimuleren, maar weten zij niet zeker of hogere-orde denken ook geschikt is voor 'zwakke' leerlingen en voelen zij zich afhankelijk van contextfactoren (zoals kant-en-klare materialen) om het hogere-orde denken te kunnen stimuleren.

Op basis van deze bevindingen hypothetiseren wij dat het voor profiel 2 leerkrachten belangrijk is om de ondersteuning te richten op het vergroten van hun zelf-ingeschatte bekwaamheid en het verlagen van hun gevoelens van afhankelijkheid van contextfactoren. Dit zou gedaan kunnen worden door deze leerkrachten te betrekken in attitude-gerichte professionalisering. Bij een dergelijke professionalisering zou de nadruk kunnen liggen op het vergroten van gevoelens van zelfvertrouwen en het vergroten van het bewustzijn over de eigen attitudes van leerkrachten.

Verder zijn er ook (meestal aanstaande) leerkrachten met een neutrale houding ten opzichte van het gebruik van nieuwe technologie maar een negatieve houding ten opzichte van het stimuleren van hogere-orde denken bij leerlingen (profiel 3). Interessant is dat bijna alle leerkrachten met een dergelijke houding afkomstig waren van één specifieke lerarenopleiding. Om deze leerkrachten in opleiding te ondersteunen, zou het dus belangrijk kunnen zijn om rekening te houden met het onderwijsprogramma.

Op basis van de uitkomsten en ervaringen van deze studies, denken wij dat leerkrachten zich bewust moeten worden van de relevantie, het plezier en de mogelijkheden die ontstaan wanneer leerlingen innovatief en creatief denken en in staat zijn om nieuwe technologieën te gebruiken om ideeën en inzichten op te doen, te delen, te verbeteren en te creëren. Dan kunnen ze leerlingen te laten zien dat school niet alleen gaat om leren lezen, schrijven en feiten uit het hoofd leren, maar dat écht leren gaat over jezelf uitdagen, ideeën verkennen en samenwerken met andere mensen en de technologische hulpmiddelen die beschikbaar zijn om dit te kunnen bereiken.

# Publications and presentations

## Scientific research articles

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2021). Primary school teachers' attitudes toward technology use and stimulating higher-order thinking in students: A review of the literature. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2021.1991864

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2021). Measuring primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and validation of the SHOT questionnaire. *Thinking Skills and Creativity, 42*. https://doi.org/10.1016/j.tsc.2021.100954

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2022). *Measuring primary school teachers' attitudes towards new technology use: Development and validation of the TANT questionnaire.* [Manuscript submitted for publication]

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2022). *Primary teachers' attitudes towards using new technology and stimulating higher-order thinking in students: A profile analysis.* [Manuscript submitted for publication]

## Conference presentations

Wijnen, F.M., J.M. Voogt, & Walma van der Molen, J.H. (2018, June). *Wanneer zetten basisschoolleerkrachten technologie in om hogere-orde denken te bevorderen [When do primary school teachers use technology to stimulate higher-order thinking]*. Paper presented at OnderwijsResearchDagen, Nijmegen.

Wijnen, F.M., Voogt, J.M., & Walma van der Molen, J.H. (2019, June). *Het meten van leerkracht-attitudes t.o.v. technologiegebruik en stimuleren van hogere-orde denken bij leerlingen [Measuring teacher attitudes towards technology use and stimulating higher-order thinking in students].* Paper presented at OnderwijsResearchDagen, Heerlen

Wijnen, F.M., Voogt, J.M., & Walma van der Molen, J.H. (2020, January). *Primary school teachers' attitudes towards technology use and stimulating higher-order thinking: Development of two questionnaires*. Paper presented at ICSEI 2020, Marrakech, Marokko.

## Presentations

Wijnen, F.M. (2017). *Technologie als tool voor 21e eeuws leren*. Poster presented at ELAN symposium. Enschede, 18 mei 2017.

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2018, maart). How do primary school teachers use technology to stimulate higher-order thinking in learners? Poster presented at the ICO International Springschool, Kerkrade

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2019). Measuring primary school teachers' attitudes towards new technology use and stimulating higher-order thinking. Paper presented at the ICO National Springschool, Amstelveen

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2019). Nieuwe technologie en hogere-orde denken in het basisonderwijs [New technology and higher-order thinking in primary education]. Workshop at the W&T Netwerkmiddag, Saxion Enschede

Wijnen, F.M., Walma van der Molen, J.H., & Voogt, J.M. (2019, mei). Nieuwe technologie en hogere-orde denken in het basisonderwijs. [New technology and higher-order thinking in primary education]. Workshop at the W&T Netwerkmiddag, Saxion Deventer.

## Practice publications

Wijnen, F.M., Rougour, T., & Schutte, P. (2021). Hogere-orde denken stimuleren met technologie: praktijkboek voor de basisschoolleerkracht [Stimulating higher-order thinking with technology: practical guide for the primary school teacher]. Deventer: TechYourFuture, Centre of Expertise.

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