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

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ABSTRACT

In order to gain insight into the factors that make up primary school teachers' attitude toward using technology for stimulating higher-order thinking, we conducted two separate literature reviews on teachers' attitudes toward (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 Behavior. We identified nine factors related to primary school teachers' attitudes toward using technology in their teaching and four factors related to primary school teachers' attitudes toward 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 behaviors stimulating higher-order thinking, respectively.

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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., analyzing, evaluating, creating) in order to find a solution or make a decision, prediction, judgment 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 (ISTE), 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

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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 toward 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 toward 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 toward using technology and toward stimulating higher-order thinking.

The present study

Our original intent was to identify factors that make up primary school teachers' attitude toward 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 toward 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 toward using technology in their teaching and (2) teachers' attitudes toward stimulating higher-order thinking in students.

We see three important reasons for conducting separate reviews. First, teachers may have *differing attitudes* toward technology use and stimulating higher-order thinking. For example, a teacher might have a positive attitude toward technology use, but a negative attitude toward 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 toward using technology. Third, because we aimed to explore teachers' attitudes toward *two different behaviors*, 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 toward 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 toward stimulating higher-order thinking in their students and to what extent do these factors influence teachers' intended or actual behavior 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 toward using technology. However, providing online teaching does not necessarily mean that teachers used technology to stimulate higher-order thinking, or that their attitudes toward 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 toward technology use in teaching and toward 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 toward using technology in teaching and toward 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 toward using technology in teaching. In Part 2, we describe the method and results of our second literature review, on teachers' attitudes toward 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 behavior

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

According to the TPB, human behavior is guided by three types of subjective perceptions or beliefs: (1) perceptions about the consequences of the behavior (behavioral 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 behavior (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 behavior.

Based on this conception of attitude, we view attitude as an umbrella term, consisting of three dimensions that together form a person's attitude toward a particular behavior. These dimensions are comprised of factors that are specific for each behavior. The first dimension, *perceptions of behavioral attributes,* represents beliefs and feelings a person associates with the specific behavior, 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 behavior. The third dimension, *perceptions of behavioral control*, represents the person's perception of the level of control he/she has as far as performing the behavior. 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 behavior, 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 behavioral 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 behavioral intention to perform or not perform that specific behavior (Ajzen, 1991). It is assumed that the stronger an intention, the more likely it is that the person will enact the behavior (Ajzen, 1991).

In both reviews, we used the TPB as a framework to analyze 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 toward (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 behavior in a number of contexts (for a meta-analytic review on the TPB, see Armitage & Conner, 2001).

Teachers' attitudes toward 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).

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 behavioral 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 toward 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., 2015), 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 toward technology use *in general* (e.g., Christensen & Knezek, 2009) rather than their attitudes toward 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 analyze and structure the attitudinal factors that make up primary school teachers' attitudes toward using technology in teaching.

Teachers' attitudes toward 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

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 Behavior 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)

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 toward 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 analyzing, 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 analyzing, evaluating and creating) in order to find a solution or make a decision, prediction, judgment or product.

Despite the commonly held idea that stimulating higher-order thinking skills in students is important, there is little research on teachers' attitudes toward teaching behaviors 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 toward 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 toward stimulating higher-order thinking by using the TPB to structure our analysis of the literature that addresses this topic.

Part 1: teachers' attitudes toward 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 analyzed 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 toward using technology in teaching. Furthermore, we analyzed 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, Supplementary material). 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 behaviors, 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 toward using technology in teaching. With this step, another 595 documents were excluded. Next, we analyzed 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 analyzed.

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 analyzed 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 behavior. 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).

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

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 labeled 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.

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 analyzed underscored our prior observation that the construct of teachers' attitudes toward using technology is often poorly defined (e.g., Steiner & Mendelovitch, 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, Supplementary material 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.

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.

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

Factor	Definition	Number of studies	Types of data*		
			Qualitative	Quantitative	Mixed
Cognitivedimension					
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 behavioral 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.

(2016) found no significant effect of AX on teachers' preparedness to plan lessons that involve the use of 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 behavioral 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 labeled 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 & Esprívalo Harrell, 2018; Jones, 2017; Khanlari, 2016; O'Neal et al., 2017; Tonui et al., 2016), time (Bingimlas, 2017; Frazier et al., 2019; González-Carriedo & Esprívalo Harrell, 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.

Part 2: teachers' attitudes toward stimulating higher-order thinking

Method

For this review, we used the same steps as for our review in Part 1 on teachers' attitudes toward 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, Supplementary material.

Similar to our review on teachers' attitudes toward 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 toward 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 cutoff point for selecting literature, resulting in a set of 690 documents. We again excluded dissertations (68), resulting in 622 documents.

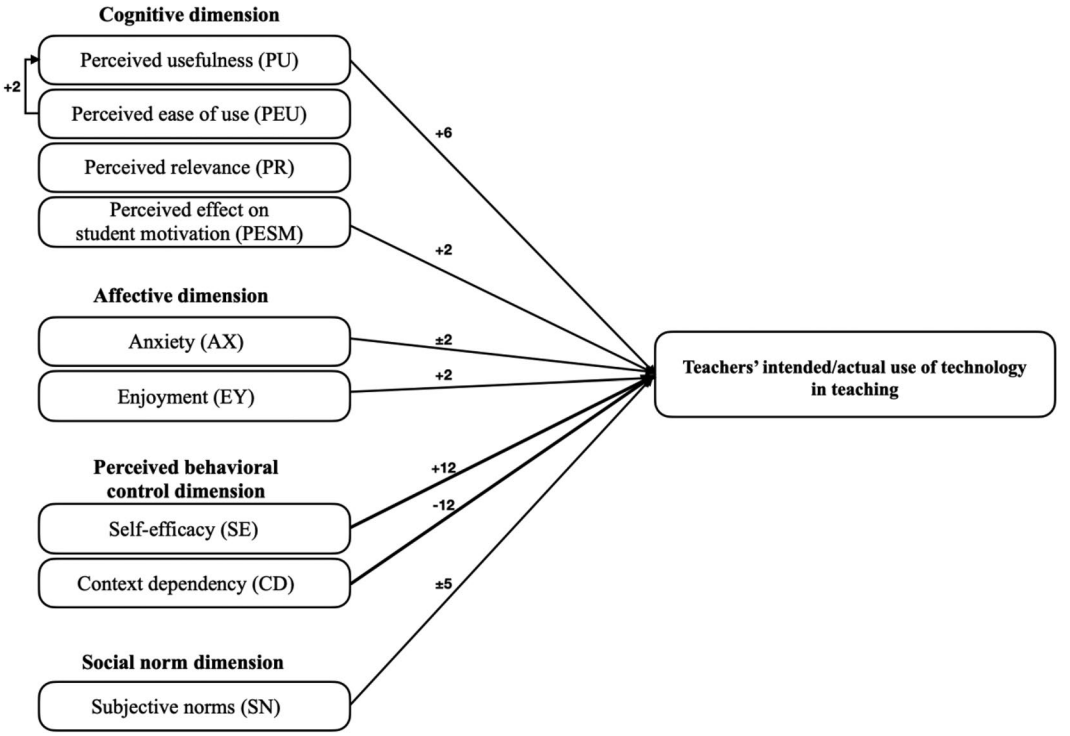

Figure 1. Studies investigating the influence of the attitudinal factors on teachers' (intended) use of technology in teaching.

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.

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 toward stimulating one or more higher-order thinking skills. With this step, 540 documents were excluded. Then, we analyzed 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 analyzed 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 behavior. 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).

Identification of attitudinal factors. Because we had no initial categorization available for this review, analysis of the documents was done inductively. The first author labeled 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 toward 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 behavior 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., 2010), 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 behavior 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 behavior 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

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

to identify several attitudinal factors (see Appendix D, Supplementary material 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, Supplementary material 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

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

		Number of studies	Types of data		
Factor	Definition		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		–	–	–	–

level of intelligence, are capable of engaging in higher-order thinking.

Perceived behavioral 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.

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 toward stimulating higher-order thinking in students compared to teachers' attitudes toward 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 behavioral 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 behavior aimed at stimulating higher-order thinking in students. These results emphasize the need to study primary school teachers' attitudes toward 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.

Overall discussion

In the present study, we conducted two separate literature reviews to identify factors that make up primary school teachers' attitudes toward using technology *and* toward stimulating higher-order thinking. As indicated in our introduction, we used the attitudinal structure that is outlined in the Theory of Planned Behavior (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

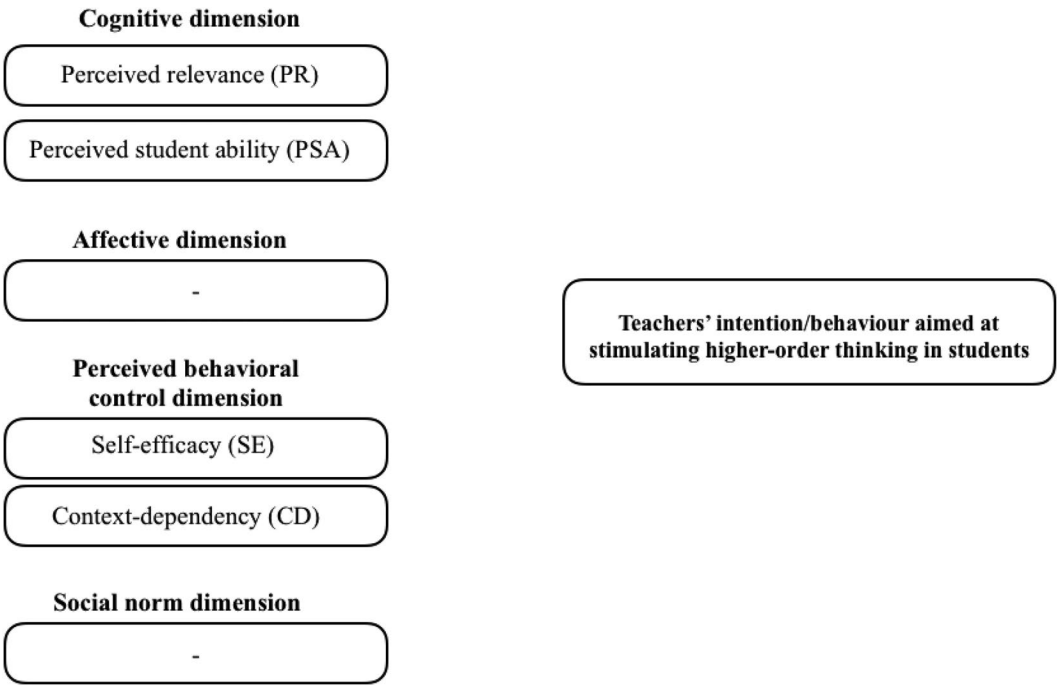

Figure 2. Studies exploring the influence of the attitudinal factors on teachers' intention/behavior aimed at stimulating higher-order thinking in students. Notes: 1. No studies reported on the influence of the identified factors on teachers' intention/

insight into these two types of attitudes and related behaviors is a first step toward 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 toward using technology in their teaching and four factors related to primary school teachers' attitudes toward stimulating higher-order thinking (see Tables 3 and 5). Our review showed a messy picture of research on teachers' attitudes toward 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 toward 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 toward technology is lacking, we argue that this is because most studies started from an incomplete theoretical basis in studying teachers' attitudes toward technology use. We therefore advise researchers who study teachers' attitudes toward technology integration to start from a sound theoretical framework, such as the TPB. Our review showed a similar picture for studies about teachers' attitudes toward 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 behavior We see a need for studies that explore the influence of the attitudinal factors on teachers' technology use and teaching behavior 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 toward stimulating higher-order thinking pertain to only two dimensions (the cognitive and perceived behavioral 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 toward 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 toward 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 reevaluate 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 behavior 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 behavior.

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 toward technology use have changed. In addition, we do not yet know whether and how this might affect teachers' attitudes toward higher-order thinking and the use of technology for stimulating higher-order thinking. By identifying factors that make up primary school teachers' attitudes toward technology use and toward higher-order thinking, our study may provide a solid basis to further study the effects of the pandemic in this regard.

Notes on contributors

Frances Wijnen is a PhD-student at the University of Twente. Her research focuses on primary school teachers' attitudes towards using new technology in teaching and towards stimulating higher-order thinking (critical thinking, creative thinking and problem solving) in students.

Juliette Walma van der Molen, focuses her research on how young people learn in technology, using various resources. In addition, she investigates possibilities for the professionalization of teachers and the implementation of new educational strategies to stimulate the creativity and scientific thinking talent in children.

Joke Voogt, conducts research into the various roles of information and communication technology (ICT) in the curriculum. For example, she studies the influence of ICT on goals and content (e.g., safe media use, information skills and 21st century skills) of the curriculum as a result of the increasing role of ICT in the knowledge society.

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