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Teachers in school-based technology innovations: A typology of their beliefs on teaching and technology

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ABSTRACT

In many innovations in technology and education in secondary schools, teachers are the crucial agents of these innovations. To select, match and support groups of teachers for particular school projects, school principals could be supported with insights into teachers' beliefs about teaching, learning and technology. A teacher typology has been developed based on an online questionnaire completed by 1602 teachers from 59 Dutch secondary schools. Teachers are grouped on the basis of their beliefs about learned-centered teaching and attitudes towards technology, which underlie the school innovations that form the context of the current research. Five teacher types are distinguished: 1) Learner-centered teachers with technology, 2) Teachers critical of technology use in school, 3) Teachers uncomfortable with technology, 4) Teachers uneasy with learned-centered teaching and 5) Teachers critical of a clear-cut stance. This classification of teachers into these five types could be used to select or match the right group of teachers to a particular intervention or to organize different professional development activities for different types of school teachers.

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1. Introduction

The increasing use of technology in society in combination with attention for constructivist learning orientations requires secondary schools to change to more suitable learning and teaching practices. As a consequence, teachers have to change accordingly, whether they perceive the required change similarly or not. Often teachers are treated as objects that must be changed, instead of agents of changes in school (Hennessy, Ruthven, & Brindley, 2005; Luttenberg, Imants, & van Veen, 2013). Innovations in teaching with technology are no exception and subsequently changes in this domain have entered the school sporadically: most classroom teachers use the technology to do what they always have done and choose those activities that will help them accommodate their own perspectives on teaching and learning (Liu, 2011; Orlando, 2013). The problem seems to be how to diffuse innovations in both technology and education at the same time. The context of the study reported in this paper is an initiative of the Dutch government to enhance the use of technology in secondary schools in a more learner-

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centered way. Schools were invited to submit their proposals and 59 secondary schools received finances to develop and implement various school-based innovations on learner-centered teaching with technology. These innovations were in different phases of implementation, ranging from initial developments to continuing innovations that were tried out in earlier years. The success of these innovations heavily depended on the teachers who should apply these in their classes. Therefore, the objective of the current study is to provide a typology of secondary school teachers based on their beliefs about teaching and technology, which could provide information for selecting, matching or supporting groups of teachers linked to the technology innovations schools would like to implement.

1.1. Technology acceptance models

Given the critical contribution that teachers can make in supporting the integration of computer technology in classrooms, to understand teachers' acceptance of technology becomes crucial. The successful use of technology in teaching and learning depends on the factors that significantly influence teachers' acceptance, intention to use and actual use of technology. One of the first models that included both technological and psychological factors affecting technology acceptance was the Technology Acceptance Model (TAM; Davis, 1989). TAM proposed the perceived usefulness and perceived ease of use to be the fundamental determinants of a teacher's intention to use technology in class. Perceived usefulness refers to the degree to which teachers believe technology supports their teaching in an efficient and productive manner. Perceived ease of use describes the extent to which teachers think that the use of technology will be relatively free of effort. The TAM-model was expanded to TAM2 and TAM3. TAM2 (Venkatesh & Davis, 2000) also included aspects of social influence and TAM3 (Venkatesh & Bala, 2008) was broadened with user factors such as self-efficacy and computer anxiety. Despite all of the refinements, TAM was more technology-oriented and less user-oriented, and therefore did not take into account some crucial individual psychological factors.

The Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Morris, Davis, & Davis, 2003) was designed by synthesizing prior technology-acceptance research. The four key constructs that influence teachers' intention to use a technology and/or technology use were 1) Performance expectancy (the degree to which using a technology will provide benefits to teachers' teaching practice), 2) Effort expectancy (the degree of ease associated with teachers' teaching with technology), 3) Social influence (the extent to which teachers perceive that others in school believe they should use technology), and 4) Facilitating conditions (which refer to teachers' perceptions of resources and support available to use technology). In UTAUT2 (Venkatesh, Thong, & Xu, 2012), the original model was elaborated with three other key constructs: 5) Hedonic motivation (fun or pleasure derived from using technology), 6) Price value (cognitive trade-off between perceived benefits of using technology and the costs for using them), and 7) Habit (the extent to which teachers believe technology use is automatic). Raman and Don (2013) applied an adapted version of UTAUT2 to preservice teachers' acceptance of Learning Managament Systems (LMS) and reported weak direct and indirect effects of these key constructs on preservice teachers' use of LMS. In contrast to Venkatesh et al. (2012), Raman and Don reported large correlations between the seven key constructs which might imply problems with the construct validity of the measurement of UTAUT2 factors.

Kreijns and colleagues (Kreijns, Vermeulen, Kirschner, van Buuren, & van Acker, 2013) proposed to apply the Integrative Model of Behavior Prediction (IMBP; Fishbein & Ajzen, 2010) to explain teachers' willingness to use technology in their pedagogy. In IMBP of Kreijns and colleagues, three key constructs (Attitudes, Perceived Norm and Self-efficacy) were hypothesized to influence teachers' intentions to use technology, which, together with skills and environmental constraints, influences teachers' actual use of technology. Attitude is the general sense of favorability regarding technology use. Perceived norm is a function of beliefs about the level of expected support from stakeholders in school, the extent to which these stakeholders use technology themselves and the motivation to comply with these referents. Self-efficacy is teachers' perceived capability in using technology. Based on a review of research into technology use of teachers, Kreijns et al. (2013) concluded that IMPB provided a parsimonious model to explain factors that influence technology use of teachers. The crucial role of technology-related teacher characteristics such as attitudes, self-efficacy and social norm in the domain of teaching with technology is confirmed in several other studies (e.g., Admiraal, Lockhorst, Smit & Weijers, 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Hermans, Tondeur, van Braak, & Valcke, 2008; Petko, 2012; Player-Koro, 2012).

What these models of technology acceptance have in common is that they try to explain teachers' adoption of technology, with a focus on technology-related factors. Yet Ertmer (1999) described two types of barriers, first- and second-order, of teaching with technology integration. First-order barriers refer to missing or inadequately provided resources such as equipment, training and support. These are usually the barriers concentrated on first in reform efforts and might be easily removed once money is provided. Second-order barriers require more fundamental changes and are typically rooted in teachers' core beliefs about teacher–student roles, teaching methods and teaching with technology. These second-order barriers include technology-related teacher characteristics as included in the technology-acceptance models as well as teachers' beliefs on effective teaching. Hermans and colleagues (Hermans et al., 2008) convincingly argue that the latter should be addressed in studies on integration of technology in schools.

1.2. Beliefs on effective teaching

The literature conveys a wide spectrum of teachers' conceptions of what constitutes effective teaching, with a teacher-centered approach focusing on knowledge transmission at one end and a learner-centered approach at the other (Alger,

2009; Barkatsas & Malone, 2005; Kim, Kim, Lee, Spector, & DeMeester, 2013; Orlando, 2013). Moreover, there is a conception which actually seems to fall outside the teacher-centered or learner-centered approach as this perception assumes that it makes no difference how teachers teach. Biggs and Tang (2011) call this the level 1 theory of teaching and learning in which the focus is on who the student is. They argue that teachers who have this as their underlying theory of teaching believe that the differences in learning outcomes are based on the various types of students: good students will get high marks, poor students will get lower marks. Whether a student will be successful in their studies depends on the motivation and prior knowledge of the student, not on the way the teacher teaches.

At the next levels described by Biggs and Tang (2011), the focus is on what the teacher does, as students are expected to passively take in the information the teacher offers in a presentation. For these teachers their only responsibility is to be experts in their fields and to expound the subject content clearly to the students in a well-organized way, usually by means of lecturing. Aspects of this approach would include four of the seven conceptions that Samuelowicz and Bain (2001) put forward: 1) imparting information, 2) transmitting knowledge which is structured by the teacher, 3) providing and facilitating understanding, and 4) helping students develop expertise which they may need later in their jobs. According to Maclellan (2014), this traditional approach to teaching, which sees students at the receiving end, still continues and -despite the large body of research pointing to the effectiveness of a learner-centered approach-this approach to teaching still tend to be common in secondary education (Meirink, Meijer, Verloop, & Bergen, 2009).

The shift in focus from what the teacher does to what the learner does is described by Biggs and Tang (2011) as a level-3 theory. In this approach, teachers' conceptions about the relationship between learning and teaching take a central place and teachers see it as their role to prevent misunderstandings, to create a learning environment of negotiating meaning and to encourage knowledge creation (Samuelowicz & Bain, 2001). This constructivist approach to learning is taken one step further towards a co-constructivist approach relying on dialogue for learning, be it with the teacher or with peers (Biggs, 2012).

Whether understood as opposites of one dimension or as two separate dimensions, these levels of beliefs on effective teaching are commonly assumed to be related to teachers' use of technology, with the more constructivist ideas teachers hold, the more they are willing to use technology in class. Moreover, an underlying motivation for technology integration in school often is that teachers will transform their teaching to constructivist practices as a consequence of their use of technology (c.f., Orlando, 2013) . However, empirical evidence on the relationship between teachers' use of technology and their constructivist beliefs about teaching is ambiguous.

1.3. Teachers' constructivist beliefs and technology use

As described above, teacher-centered beliefs are based on an assumption of knowledge delivery that resembles traditional teaching methods and underscores the importance of knowledge reproduction, while learner-centered beliefs emphasize student responsibility for learning and are focused on knowledge construction and on how students are induced to work and learn together. A positive relationship is assumed between the use of technology and constructivist teaching approaches as technology might be better suited to support these teaching and learning activities compared to traditional teaching methods.

However, empirical evidence about the relationship between constructivist beliefs and use of technology in class is not conclusive, as teachers' constructivist beliefs do not always reflect their practices or their teaching with technology has been limited to small additions to the conventional practices of teaching (e.g., Chen, 2008; Judson, 2006). In a multiple-case study of 11 primary teachers in Cyprus, Mama and Hennessy (2013) developed a typology based on teachers' educational and technology beliefs and their actual practice of the use of technology. Only two out of the 11 teachers could be classified as teachers with both constructivist beliefs and practices; eight other teachers held similar beliefs about teaching and learning, but showed an inconsistent practice of teaching with technology. The authors suggested that this inconsistency between beliefs and practice might be typical for Cyprus and other contexts where the integration of educational technology was still in its infancy. However, similar findings are reported in other research contexts. In a questionnaire study with 1120 primary school teachers in Taiwan, Liu (2011) found that most Taiwanese teachers held learner-centered beliefs, but did not integrate them with constructivist teaching with technology. In a longitudinal study of five primary and secondary school teachers in Australia, Orlando (2013) confirmed this lack of relationship between technology integration and learner-centered teaching beliefs. The author concluded that teachers are making uses of technology in educationally valuable ways albeit not in alignment with a constructivist approach.

Yet in many other studies, a positive relationship has been found between technology use and constructivist beliefs on teaching and learning. In a questionnaire study with 22 primary and secondary teachers in Taiwan, Kim et al. (2013) found a relationship between teachers' beliefs about effective ways of teaching and technology integration practices, with the more teachers held learner-centered beliefs the more seamless the integration of technology in their teaching. This finding was confirmed in a questionnaire study with 525 primary teachers in Flanders. Hermans et al. (2008) showed that teacher beliefs were significant determinants in explaining why teachers adopt computers in the classroom. Next to the impact of computer experience, general computer attitudes and gender, the authors found a positive effect of constructivist beliefs on the classroom use of computers. Traditional beliefs had a negative impact on the classroom use of computers. Also in Flanders, Tondeur, Hermans, van Braak, and Valcke (2008) reported that the self-reported uptake of the use of computers in class was the highest for teachers with relatively strong constructivist beliefs *and* traditional beliefs about teaching and learning.

Despite the ambiguous relationship, teachers' beliefs on effective teaching and learning are relevant components to be considered when studying innovations in teaching with technology. In an a multiple-case study of 12 teachers, Ertmer et al. (2012) report that primary and secondary teachers with learner-centered beliefs tended to enact learner-centered teaching despite technological, administrative, or assessment barriers. The sample these authors studied consisted of 12 award-winning technology-using teachers, which might be an explanation for the dominant influence of teacher beliefs as these teachers did not worry too much about technology-related aspects.

1.4. Typologies of teacher beliefs on teaching, learning and technology

From the literature on teaching with technology mentioned above, the problem seems to be how to diffuse learner-centered teaching and innovations in technology at the same time. The context of the study is an initiative of the Dutch government to support schools in innovations that aim at changing teaching practices in the direction to learner-centered teaching with technology. These innovations were in different phases of implementation, ranging from initial development to continuing innovations that were tried out in earlier years. The success of these innovations heavily depended on the teachers who applied these technology innovations in their classes. Earlier studies provide potential teacher typologies, which might be used as reference for the current study. For example, Tondeur et al. (2008) developed a typology of elementary school teachers based on a questionnaire about traditional and constructivist teaching beliefs. Four teacher types were distinguished with low or high mean scores on either traditional or constructivist beliefs. It appeared that teachers with relatively high scores on both traditional and constructivist beliefs were the teachers who most frequently used technology in class. But the information about teaching with technology was not part of the typology itself. Tubin (2006) did develop a typology based on information about both teaching and technology, but about technology implementation at the school level. The author distinguished four types of schools: 1) traditional ones -schools that implement technology without changing teaching methods and technology infrastructure-, 2) jet carriage type – schools that update technology infrastructure without changing teaching practices-, 3) emergent type – schools that both update technology and innovative teaching practices, and 4) exploitation type – schools that still use innovative teaching practices with an outdated infrastructure. Finally in his landmark work on diffusion of innovations, Rogers (2003) classified innovativeness at the individual level with a categorization that refers to the adoption of a particular innovation: innovators, early adopters, early majority, late majority and laggards. Yet these typologies are about implementation of innovations in general (Rogers, 2003), centered on only one of the aspects of teaching with technology (Tondeur et al., 2008) or at the school level (Tubin, 2006). Typologies about teaching with technology do exist at the level of individual teachers, but these are based on small-scaled studies and have the form of case descriptions (e.g., Mama & Hennessy, 2013; Prestridge, 2012). Therefore, we formulated the following research question:

"Which types of secondary school teachers can be distinguished based on their beliefs about learner-centered teaching and attitudes towards technology?"

2. Methods

2.1. Procedure

Data have been collected from an online questionnaire. For each of the 59 schools that participated in the government initiative mentioned above, one teacher was assigned as the corresponding teacher, who was the link between the research group and the particular school. December 2015 a link to the online questionnaire was sent to these corresponding teachers with the request to send this link to all teachers in their school. The online questionnaire was open for 3 months and several reminders were sent to the corresponding teachers.

2.2. Participants

Participants were 1602 teachers from 59 secondary schools in the Netherlands. For 15 schools, 10 or less teachers completed the online questionnaire. For the remaining 44 schools, the number of participating teachers varied from 13 to 84, with an average response rate of about 60% for the teachers who were invited to complete the questionnaire. In total, the

Table 1
Teachers' age and teaching experience (N = 1602).

Teachers' age	N	Teachers' teaching experience	N
<26 years	97	<1 year	82
26-30 years	217	1-3 years	168
31-35 years	185	4-5 years	169
36-40 years	173	6-10 years	332
41-45 years	178	11-20 years	443
46-50 years	178	21-30 years	188
51-55 years	217	>30 years	220
>55 years	357		

response rate was about 35% for the total set of all 59 schools. The sample of 1602 secondary school teachers consists of 850 females (53%). Information about teachers' age and teaching experience is summarized in Table 1, showing teachers of all ages and a majority (74%) with more than 5 years teaching experience.

Teachers were asked to indicate whether they will participate in the particular innovation of their school. In total, 334 teachers (21%) indicated that they will participate and 907 (57%) indicated that they will not be part of the school innovation project; 138 (9%) were undecided and 223 (14%) reported that they had no knowledge of these projects (which probably means that they will not participate).

2.3. Measures

In addition to teachers' background information, we measured teachers' beliefs about teaching and learning with 35 items (Questionnaire Beliefs about teaching and learning of Meirink et al., 2009) and attitudes towards technology with 19 items (Admiraal et al., 2013). These items were grouped into seven scales, as originally used in the validated questionnaires of Meirink et al. (2009) and Admiraal et al. (2013). Four scales refer to teachers' beliefs about teaching and learning: 1) Teacher-centered - cognitive (TCC), 2) Teacher-centered - affective (TCA), 3) Learner-centered - cognitive (LCC), and 4) Learner-centered - affective (LCA). TCC refers to teacher-centered instructional activities with example items such as "Students learn more when a teacher instructs them exactly what they have to do" and "Students learn more when a teachers gives detailed feedback how to improve their assignments". TCA includes teacher-centered activities that focus on student emotions with example items such as "It is important that a teacher sets student at ease before a test" and "Students learn more when a teacher takes care that students are distracted at least as possible". LCC refers to teaching that is focused on students' regulation of their learning process with example items such as "Students learn more when they reflect on their performance" and "Students learn more when they reflect on how to handle a particular task". Finally, LCA includes items that describe teaching activities that trigger students' activities to deal with their feelings with example items such as "It is important that students reflect on how they can cope with feelings of anxiety and uncertainty" and "Students learn more when they understand their emotions".

The three other scales refer to teachers' beliefs about technology and education: teachers' positive attitudes towards using technology in teaching (AT), their feelings of self-efficacy in the domain of teaching with technology (SE), and their perceived social norm of teaching with technology (SN). Example items are "The use of technology improves my teaching" and "The use of technology makes my work more satisfying "(AT), "I am able to use technology in an effective way" and "I can teach with technology without the help of others" (SE), and "In our school, technology has an important place in teaching" and "My colleagues think teaching with technology is important" (SN).

Participants rated their beliefs on a 5-point Likert type scale, with 1 = "does not apply at all" to 5 = "applies to a large extent". The reliabilities of the scales, in terms of Cronbach's α, were satisfactory. The descriptive statistics as well as the reliabilities are presented in Table 2, showing higher mean scores for learner-centered beliefs about teaching and learning.

2.4. Analyses

In order to develop a typology of teachers' beliefs about learner-centered teaching with technology, we performed cluster analyses with the five of the seven scales as input (LCC, LCA, AT, SE and SN). As teacher-centered beliefs about teaching are less relevant for the particular school innovations of the current research context and in many studies not discriminating in predicting teachers' technology adaptation (see e.g. Liu, 2011), both scales on teacher-centered beliefs were not used as input variables in the cluster analyses. We decided to use the (squared) Euclidean distance as similarity measure. Seven hierarchical clustering methods and one partitioning method (K-means) that are available in SPSS-version 24 were evaluated. In order to ascertain the optimal cluster analysis for our data, we used the Variance Ratio Criterion (VRC, see Calinski & Harabasz, 1974), combined with ω, which refers to the decrease in VRCs between two successive outcomes of cluster analyses. The VRC refers to the ratio of the 'within variance' (variance explained by the typology) and 'between variance', corrected for the number of clusters and responses. The statistic ω refers to relative loss of variance explained by using less clusters. This means that the

Table 2
Teachers' beliefs on teaching, learning and technology.

	Mean	SD	Cronbach's α
Teaching and learning			
TCC (7 items)	3.354	0.647	0.772
TCA (8 items)	3.586	0.624	0.783
LCC (10 items)	3.869	0.771	0.928
LCA (10 items)	3.624	0.669	0.888
Technology			
AT (6 items)	3.461	0.891	0.904
SE (7 items)	3.511	0.902	0.913
SN (6 items)	3.559	0.864	0.890

most optimal solution from the cluster analyses has the highest VRC score and the lowest ω. Solutions of the hierarchical clustering methods with the squared Euclidean distance showed better or equal results compared to the ones with simple Euclidean distance.

The partitioning cluster method K-means showed the highest VRCs compared to all hierarchical clustering methods. Within the solutions with the K-means clustering method, the solution with two clusters showed the largest VRC, but was not very informative with one group of 1074 teachers with relatively high average scores on all variables and one group of 528 teachers with relatively low average scores on all input variables. Then the three-cluster solution showed the largest VRC and the smallest ω (−44.43). However, the three-cluster solution included one relatively small cluster (with 131 teachers) and -on average-explained only 44% variance between teachers. Therefore, we searched for a near-best solution (based on the highest VRC and lowest ω), which is the five-cluster solution based on the K-means partitioning method. This solution showed a lower VRC compared to the two- or three-cluster solution, but a similar ω (−38.18) to the 3-cluster K-means solution; all other solutions showed a clearly lower VRCs and higher ω. Moreover, the number of teachers in the five clusters was more equally distributed over the clusters compared to the two- and three-cluster solutions. On average, the clustering into five clusters explained 54% variance between teacher scores, ranging from 49% for LCA and AT to 60% for LCC. Based on this evaluation, we decided to use the five-cluster solution based on the K-means partitioning method for our typology of teachers' beliefs about learner-centered teaching and technology.

To establish the stability of the typology, K-means cluster analysis with k = 5 was ran on an approximately 50% random sample of the original 1602 teachers (n = 831). This resulted in an agreement with the original sample of Cohen's $\kappa = 0.776$ with a 95% confidence interval of $0.743 < \kappa < 0.809$. We repeated this procedure for a 25% random sample (n = 416). This resulted in an agreement between with the original sample of Cohen's $\kappa = 0.657$ with a 95% confidence interval of $0.604 < \kappa < 0.710$. These evaluations indicate that the stability of the five-cluster solution is satisfactory (c.f., Cohen, 1988).

3. Findings

3.1. Typology based on teachers' beliefs on teaching and technology

In Table 3, we summarize the typology of teachers based on their beliefs about learner-centered teaching beliefs and attitudes towards technology. For each cluster, we marked the mean scores that differed considerably from the general mean scores and/or from the cluster means on the other input variables. These marked mean scores provide the most meaningful information to interpret the results of the cluster analysis:

- Cluster 1: 444 teachers with relatively high mean scores on both learner-centered beliefs and on the technology scales.
- Cluster 2: 296 teachers with a relatively low mean score on perceived social norm of teaching with technology.
- Cluster 3: 398 teachers with moderate mean scores on learner-centered beliefs, but relatively low means scores on attitudes towards and self-efficacy on teaching with technology.
- Cluster 4: 344 teachers with relatively low mean scores on learner-centered teaching beliefs and a relatively high mean score on feelings of self-efficacy in the domain of teaching with technology.
- Cluster 5: 120 teachers with low mean scores overall.

3.2. Elaboration of the typology

In order to elaborate the interpretation of the profiles, we examined the relationships of the typology with the two scales on teacher-centered teaching (TCC and TCA) and background information (gender, age and teaching experience). Descriptive data for each cluster is summarized in Table 4. Significant relationships of the five clusters were found with both TCC ($F(1601,4) = 47.720$; $p < 0.001$; $\eta^2 = 0.107$) and TCA ($F(1601,4) = 163.203$; $p < 0.001$; $\eta^2 = 0.290$). For TCC, Scheffé post-hoc

Table 3
Five clusters with cluster mean score and SD within brackets for the input variables (LCC = learner-centered beliefs – cognitive; LCA = learner-centered beliefs – affective; AT = Attitudes towards technology; SE= Self-efficacy in teaching with technology and SN = perceived social norm of teaching with technology). Circled scores show relatively high or low mean scores, which can be understood as indicative for a particular cluster.

	Cluster 1 (n= 444)	Cluster 2 (n= 296)	Cluster 3 (n=398)	Cluster 4 (n= 344)	Cluster 5 (n= 120)
LCC	4.377 (0.395)	4.081 (0.450)	3.961 (0.505)	3.571 (0.549)	2.023 (0.636)
LCA	4.062 (0.436)	3.753 (0.497)	3.687 (0.488)	3.368 (0.457)	2. 212 (0.579)
AT	4.313 (0.484)	3.225 (0.765)	2.873 (0.663)	3.621 (0.585)	2.381 (0.801)
SE	4.119 (0.614)	3.652 (0.580)	2.635 (0.558)	4.025 (0.529)	2.351 (0.869)
SN	4.184 (0.529)	2.651 (0.574)	3.661 (0.568)	3.894 (0.528)	2.188 (0.742)

Table 4
Five clusters with cluster mean score and SD within brackets for teachers' beliefs about teaching and learning (TCC = Teacher-centered beliefs – cognitive; TCA = Teacher-centered beliefs – affective), and within-cluster percentages for teachers' background variables (gender, age, and teaching experience). Circled scores show relatively high or low mean scores (for teacher beliefs) or relatively high within-cluster percentages (for background variables), which can be understood as indicative for a particular cluster.

	Cluster 1 (n= 444)	Cluster 2 (n= 296)	Cluster 3 (n=398)	Cluster 4 (n= 344)	Cluster 5 (n= 120)	Total (n= 1602)
Beliefs about teaching and learning						
TCC	3.347	3.461	3.485	3.371	2.639	3.354
	(0.639)	(0.579)	(0.596)	(0.571)	(0.747)	(0.647)
TCA	3.748	3.744	3.696	3.512	2.448	3.686
	(0.521)	(0.472)	(0.490)	(0.521)	(0.760)	(0.624)
Gender						
Male	48.9	45.3	41.0	50. 9	52.5	46.9
Female	51.1	54.7	59.0	49.1	47.5	53.1
Age in years						
< 26	5.6	5.7	2.8	10.2	7.5	6.1
26-30	14.4	15.5	8.5	16.6	13.3	13.5
31-35	11.7	12.8	7.0	16.0	10.0	11.5
36-40	13.1	13.2	8.0	9.9	8.3	10.8
41-45	13.7	12.8	9.8	9.9	5.0	11.1
46-50	10.6	11.8	11.6	10.2	12.5	11.1
51-55	11.9	12.5	17.8	11.6	13.3	13.5
> 55	18.9	15.5	34.4	15.7	30.0	22.3
Teaching experience in years						
< 1	4.7	3.7	3.3	8.4	6.7	5.1
1-3	9.5	12.5	7.0	13.4	12.5	10.5
4-5	10.6	10.5	7.3	14.0	11.7	10.5
6-10	22.5	23.3	14.6	22.7	19.2	20.7
11-20	29.5	31.1	30.2	23.0	17.5	27.7
21-30	11.3	10.1	15.6	8.7	13.3	11.7
> 30	11.9	8.8	21.1	9.9	19.2	13.7

analyses indicated significant lower scores of cluster 5 compared with all other clusters (all with $p < 0.001$) and significant higher mean score of cluster 3 compared to cluster 1 ($p = 0.032$). For TCA, Scheffé post-hoc analyses indicated significant lower scores of cluster 5 compared to all other clusters (all with $p < 0.001$) and significant lower scores of cluster 4 compared to cluster 1, 2 and 3 (all with $p < 0.001$).

With respect to the background variables, a significant relationship with gender was found ($\chi^2 = 10.347$; df = 4; $p = 0.035$), indicating relative more female teachers in cluster 3 and relatively more male teachers in clusters 1, 4 and 5. Significant relationship were also found with age ($\chi^2 = 110.554$; df = 28; $p < 0.001$) and teaching experience ($\chi^2 = 83.565$; df = 24; $p < 0.001$). Inspection of the cross tables led to similar conclusions with respect to age and teaching experience. Cluster 1 has an over-representation of teachers between 36 and 45 years of age and middle-career teachers with between 6 and 20 years of teaching experience. Cluster 2 has an overrepresentation of teachers between 26 and 45 years of age with either 1–3 years or between 6 and 20 years of teaching experience. . Cluster 3 has an over-representation of veteran teachers (51 years or older) and teachers with more than 10 years teaching experience. Cluster 4 shows an overrepresentation of relatively young teachers (35 years or younger) with teaching experience of 10 years or less. Finally, cluster 5 includes relative more veteran teachers (55 years or older) and very young teachers (26 years or less) with either 30 years of teaching experience or less than 1 year of teaching experience.

3.3. Differences between schools

The schools the participants of this study worked in were financed for innovations in the domain of learner-centered teaching with technology. Participants were asked to indicate whether they were certain to participate in the innovations in school or not. Of the total of 1602 teachers, 334 teachers indicated that they will participate in the school innovation on learner-centered teaching with technology. Chi-square test showed a relationship between the typology and teachers'

planned participation in school innovation ($\chi^2 = 52.081$; df = 12; $p < 0.001$). In cluster 1, the prospective project participants are overrepresented and in clusters 3and 4 the number of prospective project participants is relatively low (see Table 5).

Analyses of the cross tables with 29 schools with more than 25 respondents (based on the expectation to have for each school at least 5 teachers per cluster) and the five clusters revealed a significant relationship, which means that schools differ in the distribution of their teachers over the five clusters ($\chi^2 = 316.914$; n = 1239; df = 112; $p < 0.001$). The nominal association measures indicate a weak, but significant relationship between school and teacher clusters ($\varphi = 0.506$; Cramer's $V = 0.253$; Contingency Coefficient = 0.451, all with $p < 0.001$). Then we selected 9 schools with at least 10 teachers who indicated that they participated in the school innovation and had a close inspection of the cross tables of these nine schools with the five clusters of teachers. Although we should be careful with the interpretation of this table because of the low number of teachers in each cell, we noticed only two schools with relatively more participating teachers from cluster 1 (which could be seen as the favorable teacher cluster for these innovations). In these two schools as well as in three other schools, relatively more teachers (compared with the overall distribution of teachers over clusters) from cluster 4 planned to participate in the innovation. In again three other schools, this was the case for teachers from cluster 2. One school showed the average distribution of teachers across the five clusters. As indicated above, cluster-2 teachers showed a relatively low score on the social norm on teaching with technology and cluster-4 teachers a relatively low score on learner-centered teaching beliefs. So for eight of the nine schools, this distribution of teachers over the clusters might trigger school principals to undertake follow-up activities with their staff. Yet as mentioned above we should be careful with the interpretation of the numbers because of the low number of teachers per school who indicated that they plan to participate in the school innovation.

4. Discussion and conclusion

The context of this study is an initiative of the Dutch government to finance innovations of 59 secondary schools in the area of learner-centered teaching with technology. A questionnaire has been administered to explore beliefs and attitudes of the teachers from these schools. In total, 1602 teachers of these 59 schools indicated their beliefs about teaching and attitudes towards technology. Based on this information, five clusters of teachers were identified (see Table 3). In order to interpret the clusters with teachers we used additional information from the questionnaire. With this combination of teaching beliefs and technology attitudes the typology developed in the current study is more situated in technology innovations in school than the general classification of innovativeness by Rogers (2003) and more comprehensive than the typology of Tondeur et al. (2008), which focused on teaching beliefs of elementary school teachers. It also adds to the small-scale studies of Mama and Hennessy (2013) and Prestridge (2012), that were limited to case descriptions based on individual choices of teachers in a very specific context.

We also found a relationship between the typology and years of teaching experiences with the more experienced teachers holding relatively more learner-centered beliefs on teaching and learning and less positive attitudes towards technology. But this relationship is not linear as the fifth cluster (with low means scores overall) included a relatively high number of both inexperienced and very experienced teachers. This non-linear relationship is in line with findings from other empirical studies (Alger, 2009; De Vries, Jansen, & Van de Grift, 2013). For example, Alger (2009) concluded that very experienced teachers began teaching with teacher-centered beliefs and that only some of them moved toward learner-centered beliefs on teaching.

Although we suggest that learner-centered teaching beliefs and attitudes towards technology are both crucial elements of a proper typology, our findings also make clear that the relationship between both elements is not a positive linear one per se. This more complex relationship between teaching beliefs and technology attitudes aligns with the conclusions of Orlando (2013) and other researchers who already voiced doubts about constructivist practices as an underlying motive to diffuse technology innovations in schools.

4.1. Teacher typology

Below we define the five types of teachers based on our findings. These teacher types can be scaled on the degree in which teachers combine learner-centered teaching beliefs with positive attitudes towards technology. At first sight, there seems to be relationship between these five teacher types and the three levels of thinking about teaching as distinguished by Biggs and Tang (2011). Type-1 teachers generally demonstrate level-3 thinking (learner-centered ideas), whereas Type-5 teachers

Table 5
Relationship between the five clusters and teachers' planned participation in school innovation projects (in % of each cluster).

Teachers' planned participation	Cluster 1 (n = 444)	Cluster 2 (n = 296)	Cluster 3 (n = 398)	Cluster 4 (n = 344)	Cluster 5 (n = 120)
Yes (n = 334; 20.8.%)	28.8%	20.6%	14.3%	18.3%	20.8%
Undecided (n = 138; 8.6%)	11.0%	11.5%	6.3%	7.0%	5.0%
No (n = 907; 56.6%)	49.5%	53.0%	66.1%	57.8%	56.7%
No knowledge (n = 223; 13.9%)	10.6%	14.9%	13.3%	16.9%	17.5%

appear to think at level 1, with the other types at both level 2 and 3. Yet the information about technology complements beliefs on teaching and learning, resulting in a more comprehensive typology. Fig. 1 includes a graphical presentation of the five teacher types which makes clear the discriminating power of the three technology variables, compared to the two teaching beliefs variables.

4.1.1. Type 1: learner-centered teachers with technology (n = 444)

This type of teachers could be understood as the most favorable type for the school innovations in learner-centered teaching with technology, which were the research context of the current study. The mean scores on all relevant scales are relatively high. This type includes more males than females and relatively more teachers in their mid-career (6–20 years teaching experiences). These teachers are similar to the group of "Innovators" as defined by Rogers (2003), albeit that Rogers indicated that only a very small portion of teachers might be understood as Innovators in terms of teacher leaders of an innovation. Teachers in this cluster generally have level-3 notions about teaching and learning (Biggs & Tang, 2011) indicating learner-centered teaching beliefs. We label this teacher type as *Learner-centered teachers with technology*.

4.1.2. Type 2: teachers critical of technology use in school (n = 296)

This type of teachers shows relatively high mean scores on learner-centered teaching beliefs, average scores on attitudes towards technology and feelings of self-efficacy in using technology, and low scores on social norm on technology use in school. The latter means that these teachers are generally quite critical of technology use in their school. Most teachers are mid-career teachers (26–45 years of age) with 6–20 years of teaching experience. Based on their relatively low scores on social norm, we label this teacher type as *Teachers critical of technology use in school*.

4.1.3. Type 3: teachers uncomfortable with technology (n = 398)

This type of teachers shows relatively low mean scores on attitudes towards technology and feelings of self-efficacy in using technology, and mean scores on all other scales. This profile includes relatively more female teachers, more veteran teachers (51 years or older) and teachers with a lot of teaching experience (11 years or more). Based on their low technology scores, we label this teacher type as *Teachers uncomfortable with technology*.

4.1.4. Type 4: teachers uneasy with learned-centered teaching (n = 344)

This teacher type is characterized by relatively low means scores on learner-centered teaching beliefs, but a relatively high mean score on feelings of self-efficacy in teaching with technology. This cluster includes more male than female teachers and relatively more young and inexperienced teachers. The relationship between teaching beliefs and teaching experience is confirmed by Alger (2009), with starting teachers have relatively less learner-centered teaching beliefs. We label this teacher type as *Teachers uneasy with learned-centered teaching*.

4.1.5. Type 5: teachers critical of a clear-cut stance (n = 120)

This teacher type of teacher could be understood as the least favorable type of teachers for the school innovations in learner-centered teaching with technology. The mean scores on all relevant scales are relatively low. This type includes relatively more males, and teachers with either a lot of teaching experience (30 years or more) or almost no teaching

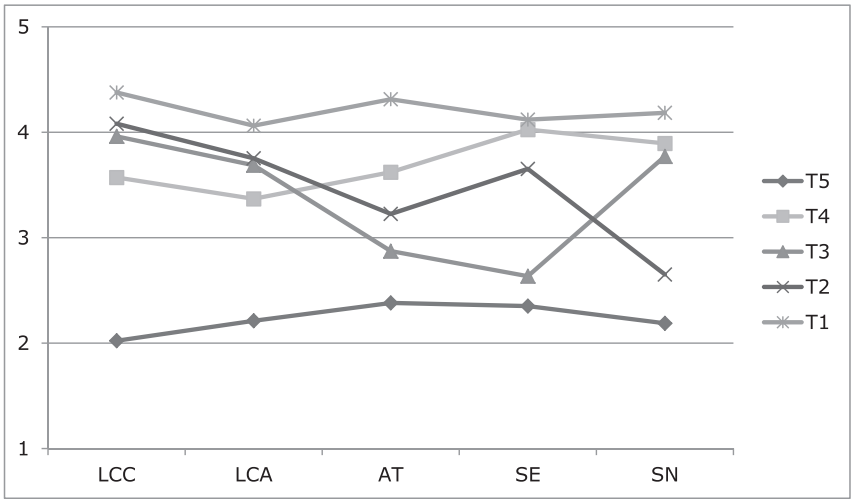

Fig. 1. Graphical presentation of the five teacher types based on the mean score of the input variables (LCC = learner-centered beliefs – cognitive; LCA = learner-centered beliefs – affective; AT = Attitudes towards technology; SE= Self-efficacy in teaching with technology and SN = perceived social norm of teaching with technology).

experience (less than one year). The low score on all beliefs about teaching and learning suggest teachers who generally think that learning outcomes are solely dependent on motivation and prior knowledge of students, not on the way teachers teach. Moreover, their low scores on the technology scales are in line with one of the types Mama and Hennessy (2013) described as a teacher with "rather negative and subversive beliefs about technology, regarding that it could usurp the teacher's role in the classroom" (p. 383). Others found that teachers hold eclectic views about teaching and learning and therefore it is difficult to classify their views into a single pedagogical belief category (e.g., Wilke & Losh, 2008). Teachers in this cluster might not be able or willing (yet) to report their explicit beliefs about teaching, learning and technology. Therefore, we label this teacher type as *Teachers critical of a clear-cut stance*.

4.2. Implications for a change towards teaching with technology in a learner-centered way

The typology of the current study could support school innovation projects by:

- selecting the right group of teachers for future technology innovations in their schools;
- matching groups of teachers to the particular school projects;
- compiling teacher teams that implement particular schools projects, and
- supporting professional development of particular groups of teachers as a start of the project.

Below we will give some examples of how groups of teachers can be supported in their change towards learner-centered teaching with technology. We did not find a consistent strong positive correlation between learner-centered beliefs and attitudes towards technology, neither in our data nor in the literature. This means that if we would like to change teaching practices into the direction of teaching with technology in a learner-centered way, we have to focus on both technology attitudes and teaching beliefs. But this can be different for different types of teachers. Supporting professional development of *Teachers critical of a clear-cut stance* (Type 5) might be the most complicated. It seems these teachers generally are not able or willing to take a clear stance with respect to teaching, learning and technology. This means that professional development activities could be focused on increasing their awareness of the value of teaching and technology and of their preferences. *Teachers who are uneasy with learned-centered teaching* (Type 4) might be supported by professional development activities that change their teaching beliefs into more learner-centered beliefs of teaching. One way to do this might be to make use of their relatively high scores on feelings of self-efficacy in using technology and stimulate them first to experiment with technology in class, give them autonomy to do so, and then support them to do this in a learned-centered way. In this way, teachers can profit from their confidence in using technology in order to develop more learner-centered teaching approaches. Professional development activities of the group of *teachers who are uncomfortable with technology* (Type 3) might be supported in a similar way. Another strategy could be to connect these teachers to other teachers with higher mean scores on technology and to challenge them to experiment with peer or team teaching with these colleagues. The group of *teachers who are critical of technology use in their school* (Type 2) might be more supported with changing their school environment into a more technology-oriented setting or at least how this environment is perceived. A strategy with peer or team teaching with more optimistic colleagues could also help, but more effective could be initiatives to increase technology awareness and to improve technology infrastructure at the level of teams or departments in which these teachers work. Finally, the group of *Learner-centered teachers with technology* (Type 1) should be supported and rewarded for taking initiatives in school, with their colleagues and with other stakeholders, in the process of establishing the quality of teaching with technology in school. If a school is successful in changing teaching with technology in a learner-centered way for all teacher types, the correlation between the pedagogical and technology dimension would be positive.

It is already known that teacher beliefs are resistant to change and that this difficulty is mainly caused by the experience teachers bring into their beliefs (Meirink et al., 2009; Pajares, 1992). Kagan (1992) stated that a conceptual change is needed to change teachers' beliefs as "experienced teachers are unlikely to modify their belief systems without some dramatic disequilibrium" (p. 78). It is less likely that a one-time effort to change teachers' beliefs is successful; this kind of fundamental changes does not happen quickly or automatically. Various strategies have been suggested to promote teacher belief change including observation, practice, reflection, and social cultural support (Kim et al., 2013). These strategies can be done through collaboration among teachers that could also change school culture. In order to facilitate collaboration, Kim and colleagues recommend both internal (within the same school) and external (beyond school boundaries) networking. Both are necessary for the teachers to share information, discuss their experiences, and guide and encourage the implementation of newer beliefs. Through the observations of other teachers' lessons, teachers can reflect on and perhaps alter their ways of integrating technology in class. In addition, a collaborative environment can give teachers more opportunities to see successful outcomes of integration of teaching and technology.

4.3. Limitations and future research

Three limitations of our study are worth mentioning. First, the typology we have developed should be interpreted at the level of groups of teachers as is the case with all person-centered approaches. The teacher types should not lead to implications for individual teachers because of two reasons. First, the input variables are measured with sets of questionnaire items

that have satisfying reliabilities for research purposes or comparison between groups of teachers, but not for diagnosing individual teachers' educational beliefs and attitudes towards technology. Second, the five teacher types are based on mean scores of groups of teachers, which are significant different between teacher types. But this does not mean that all teachers are equally near the cluster mean scores of all input variables. It might that for some beliefs some teachers are more similar to teachers from other teacher types than to other teachers who belong to the same teacher type.

A second limitation that we would like to mention here is that the typology is based on questionnaire data only. We suggest to replicate and validate the definition of the teacher types in future research by, for example, interviews with representatives of each type and with school leaders. Findings from these interviews with teachers and school leaders could also help to understand whether they recognize the teacher types and observe these types in school. Extending the typology with teachers' actual use of learner-centered teaching with technology could also be a direction for future research. As elucidated in the introduction section of this paper, there might be an inconsistency between teachers' beliefs and attitudes, on the one hand, and their actual teacher practice, on the other hand. In addition to future attempts to elaborate and consolidate the teacher types, future research could also provide insights into *how* school leaders could deal with this information and how they could benefit from it when they want to support their teachers in their professional development or match groups of teachers, teams or departments with innovations that require particular teaching beliefs and attitudes. For this, the questionnaire of this study is only a first step for reflection and awareness; additional strategies are necessary to support teachers in changing their practices and to speed up technology changes in school.

A third limitation is the sample of schools that is involved in the current study. As mentioned above, these schools might be seen "at the front end" of technology innovations in secondary education as they voluntarily submitted project proposals. In future research, the typology should be validated in other types of secondary schools.

4.4. Concluding remarks

Notwithstanding the limitations mentioned above, this study presents five types of teachers based on their learner-centered teaching beliefs and attitudes towards technology: 1) Learner-centered teachers with technology, 2) Teachers critical of technology use in school, 3) Teachers uncomfortable with technology, 4) Teachers uneasy with learned-centered teaching and 5) Teachers critical of a clear-cut stance. Linked to the school innovations that formed the research context of this study, only about a quarter of the teachers belonged to the favorable teacher type; for the other teachers their type was less optimal. This finding calls for interventions in schools to select the right group of teachers for future technology innovations in their schools, to match groups of teachers to the particular school projects, to compile teacher teams that implement particular schools projects, or to support professional development of particular groups of teachers as a start of the project.

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References

Admiraal, W., Lockhorst, D., Smit, B., & Weijers, S. (2013). The Integrative Model of Behavior Prediction to explain technology use in post-graduate teacher education programs in the Netherlands. *International Journal of Higher Education, 2*(4), 172–178.
Alger, C. L. (2009). Secondary teachers' conceptual metaphors of teaching and learning: Changes over the career span. *Teaching and Teacher Education, 25*, 743–751.
Barkatsas, A. T., & Malone, J. (2005). A typology of mathematics teachers' beliefs about teaching and learning mathematics and instructional practices. *Mathematics Education Research Journal, 17*(2), 69–90.
Biggs, J. (2012). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 31*(1), 39–55.
Biggs, J. B., & Tang, C. S. (2011). *Teaching for quality learning at university: What the student does* (4th ed.). Maidenhead, United Kingdom: McGraw-Hill Education.
Calinski, T., & Harabasz, J. (1974). A dendrite method for cluster analysis. *Communications in Statistics, 3*, 1–27.
Chen, C.-H. (2008). Why do teachers not practice what they believe regarding technology integration? *The Journal of Educational Research, 102*(1), 65–75.
Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd. ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319–339.
De Vries, S., Jansen, E. P. W. A., & van de Grift, W. J. C. M. (2013). Profiling teachers' continuing professional development and the relation with their beliefs about learning and teaching. *Teaching and Teacher Education, 33*, 78–89.
Ertmer, P. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–61.
Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*, 423–435.
Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York: Psychology Press.
Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 27*, 155–192.
Hermans, R., Tondeur, J., van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. *Computers & Education, 51*, 1499–1509.
Judson, E. (2006). How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education, 14*, 581–597.
Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65–90.

Kim, C.-M., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education, 29*, 76–85.
Kreijns, K., Vermeulen, M., Kirschner, P. A., van Buuren, H., & van Acker, F. (2013). Adopting the integrative model of behaviour prediction to explain teachers' willingness to use ICT: A perspective for research on teachers' ICT usage in pedagogical practices. *Technology, Pedagogy and Education, 22*, 55–71.
Liu, S.-H. (2011). Factors related to pedagogical beliefs of teachers and technology integration. *Computers & Education, 56*, 1012–1022.
Luttenberg, J., Imants, J., & van Veen, K. (2013). Reform as ongoing positioning process: The positioning of a teacher in the context of reform. *Teachers and Teaching, 19*, 293–310.
Maclellan, E. (2014). Updating understandings of "teaching": Taking account of learners' and teachers' beliefs. *Teaching in Higher Education, 20*, 171–182.
Mama, M., & Hennessy, S. (2013). Developing a typology of teacher beliefs and practices concerning classroom use of ICT. *Computers & Education, 68*, 380–387.
Meirink, J. A., Meijer, P. C., Verloop, N., & Bergen, Th. C. M. (2009). Understanding teacher learning in secondary education: The relations of teacher activities to changed beliefs about teaching and learning. *Teaching and Teacher Education, 25*, 89–100.
Orlando, J. (2013). ICT-mediated practice and constructivist practices: Is this still the best plan for teachers' uses of ICT? *Technology, Pedagogy and Education, 22*, 231–246.
Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307–332.
Petko, D. (2012). Teachers' pedagogical beliefs and their use of digital media in classrooms: Sharpening the focus of the 'will, skill, tool' model and integrating teachers' constructivist orientations. *Computers & Education, 58*, 1351–1359.
Player-Koro, C. (2012). Factors influencing teachers' use of ICT in education. *Education Inquiry, 3*(1), 93–108.
Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education, 58*, 449–458.
Raman, A., & Don, Y. (2013). Preservice teachers' acceptance of learning management software: An application of the UTAUT2 model. *International Educational Studies, 6*(7), 157–164.
Rogers, E. (2003). *Diffusion of innovation* (5th ed.). New York: The Free Press.
Samuelowicz, K., & Bain, J. D. (2001). Revisiting academics ' beliefs about teaching and learning. *Higher Education, 41*, 299–325.
Tondeur, J., Hermans, R., van Braak, J., & Valcke, M. (2008). Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom. *Computers in Human Behavior, 24*, 2541–2553.
Tubin, D. (2006). Typology of ICT implementation and technology applications. *Computers in the Schools, 23*(1/2), 85–98.
Venkatesh, V., & Bala, H. (2008). Technology acceptance Model 3 and a research agenda on interventions. *Decision Sciences, 39*, 273–315.
Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*, 186–204.
Venkatesh, V., Morris, M., Davis, G., & Davis, F. D. (2003). User-acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*, 425–478.
Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly, 36*, 157–178.
Wilke, R., & Losh, S. (2008). Beyond beliefs: Preservice teachers' planned instructional strategies. *Action in Teacher Education, 30*(3), 64–73.