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Teacher factors associated with innovative curriculum goals and pedagogical practices: differences between extensive and non-extensive ICT-using science teachers

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Abstract Second Information Technology in Education Study (SITES) 2006 was an international study about pedagogical practices and the use of information and communication technology (ICT) in math and science classrooms. One of the findings of SITES 2006 was that – across educational systems – a proportion of the math and science teachers in the 22 countries researched in the SITES 2006 study were using ICT extensively and their pedagogy was oriented towards lifelong learning which is considered relevant for the 21st century. Starting from this finding, a secondary analysis has been conducted to explore differences between extensive and non-extensive ICT-using science teachers with respect to pedagogical orientation, ICT competencies and professional engagement. Based on selected questions from the SITES 2006 teacher questionnaire, indicators have been developed for these constructs. Differences between the two groups were calculated using simple *t*-tests and effect sizes. The findings showed that both groups of science teachers had a pedagogical orientation that reflected traditionally important as well as lifelong learning curriculum goals and practices, but extensive ICT-using science teachers, much more than their non-extensive ICT-using colleagues pursued curriculum goals and practices that are oriented towards lifelong learning. In addition, extensive ICT-using science teachers appeared more confident about their ICT competencies and felt more professionally engaged; two factors that were also found in other studies to positively relate to a lifelong learning orientation towards teaching and learning.

Keywords Knowledge society, Information and Communication Technology, Science Education, Secondary Education, Teacher, Beliefs

Innovative curriculum goals and pedagogical practices

Through information and communication technology (ICT), the global society is developing towards an information or knowledge society. While the information society metaphor is associated with an 'explosion' of information and information systems, the knowledge society metaphor primarily refers to economic systems where ideas or knowledge functions as commodities (Anderson 2008, p. 5). It is generally accepted that the 'explosion' of information, because of the development of ICT, contributed to the development of our society into a knowledge society. In this paper, information and knowledge society are therefore used interchangeably. Many argue [e.g. European Commission 2002;

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Organisation for Economic Co-operation and Development (OECD) 2004; Voogt & Pelgrum 2005] that these developments in society should have implications for our education systems. There is a need to change curricula so that students develop competencies that are needed in the 21st century (e.g. Voogt & Pelgrum 2005; Anderson 2008). According to the European Commission, for instance, all citizens of the European Union should have the opportunity to acquire a number of so-called key skills that include digital literacy and higher order skills such as teamwork, problem solving and project management (European Commission 2002). Anderson (2008) listed required skills for the knowledge society: knowledge construction, adaptability, finding, organizing and retrieving information, information management, critical thinking and teamwork. Skills important for the knowledge society are often also referred to as lifelong learning competencies. The education ministers of OECD countries (OECD 2004) embraced the concept of lifelong learning. According to the OECD, a major feature of the concept of lifelong learning is developing the capacity of 'learning to learn'. The lifelong learning approach anticipates coping with the increased pace of globalization and technological change (OECD 2004). Several initiatives such as the Partnership for 21st Century Skills (2009) and the National Educational Technology Standards for Students (International Society for Technology in Education 2007) responded to the challenges the knowledge society poses to education in particular. Voogt (2003, 2008) argued that the required changes in curriculum goals relevant for the information society align with developments in the learning sciences (see, for example, Bransford *et al*. 2000) about learner-centred forms of instruction. She projected pedagogical approaches that are consistent with the expectations and values of the information society and showed how these might differ from those consistent with the expectations and values of the industrial society (see Table 1). Voogt (2003) argued that education needs to find a new balance between the pedagogical approaches that are considered useful in the industrial society and those that are deemed relevant for the information society. For the present study, however, we make a distinction between these two pedagogies.

SITES 2006 was an international comparative survey (conducted under the auspices of the IEA, the International Association for the Evaluation of Educational Achievement) aimed at examining the extent of ICT integration in classroom practices and at identifying factors that contribute most to effective integration of ICT into learning and teaching. Schools and grade 8 math and science teachers from 22 educational systems participated in SITES 2006. Per educational system, 400 schools and four teachers per school participated. The main international findings have been reported in Law *et al*. (2008b). A major aim of SITES 2006 also was to investigate to what extent education complied with requirements of the industrial and/or the knowledge society. In the study, a distinction has been made

Table 1. Overview of pedagogy in an industrial society versus an information society (source Voogt, 2003).

Aspect	Less (pedagogy in an industrial society)	More (pedagogy in the information society)
Active	Activities prescribed by teacher	Activities determined by learners
	Whole class instruction	Small groups
	Little variation in activities	Many different activities
	Pace determined by the programme	Pace determined by learners
Collaborative	Individual	Working in teams
	Homogeneous groups	Heterogeneous groups
	Everyone for him/herself	Supporting each other
Creative	Reproductive learning	Productive learning
	Apply known solutions to problems	Find new solutions to problems
Integrative	No link between theory and practice	Integrating theory and practice
	Separate subjects	Relations between subjects
	Discipline-based	Thematic
	Individual teachers	Teams of teachers
Evaluative	Teacher-directed	Student-directed
	Summative	Diagnostic

between pedagogical practices that were considered *traditionally important* and *emerging practices*, which were divided in into *lifelong learning orientation* and *connectedness orientation*. The latter two together were also addressed as the innovative practice orientation (see also Law & Chow 2008). Traditionally important practices reflected teaching and learning, which are considered important in the industrial society (Law *et al*. 2008b; Voogt 2009), while the innovative practice orientation tried to respond to challenges of the knowledge society.

In this paper, the SITES 2006 data were used to explore differences between extensive and non-extensive ICT-using science teachers with regard to innovative and traditionally important pedagogical practices. For this reason, the term 'innovative' should be understood in the way it was used in SITES 2006 and in particular, to the lifelong learning orientation, which is to those curriculum goals and pedagogical practices that were considered important for lifelong learning in the knowledge society. The way innovative curriculum goals and pedagogical practices as well as traditionally important goals and practices were made operational in SITES 2006 will be elaborated in the methods section.

Teacher factors associated with innovative pedagogical use of ICT

Several scholars (Mumtaz 2000; Becker 2001; Niederhauser & Stoddart 2001; Tondeur *et al*. 2008) studied the relationship between pedagogical orientation and ICT use by teachers. Tondeur *et al*. (2008) found that teachers who held a mixed constructivist and a traditional pedagogical orientation used the computer more frequently for all three types of computer use they distinguished (computer as informational tool, the computer as a learning tool and basic skills) compared with teachers who had either a constructivist or a traditional pedagogical orientation. In addition, teachers with constructivist beliefs used the computer more as an information tool compared with teachers who hold traditional beliefs. Niederhauser and Stoddart (2001) studied the relation between elementary teachers' use of software and their instructional perspectives. They found that teachers who used open-ended software were more likely to have a pedagogical orientation that is learner-centred, while teachers who used only skill-based software were more likely to have a teacher-directed orientation towards the use of computers for learning. However, Niederhauser and Stoddart also found that only a minority of the elementary school teachers used only open-ended software and that the majority used a combination of open-ended and skills-based software. Similar to the findings of Tondeur *et al*. (2008), Niederhauser and Stoddart found that elementary school teachers who used a combination of open-ended and skills-based software held a pedagogical orientation that contains learner-centred elements as well as teacher-directed elements. In summary, an association between teachers' pedagogical orientation and the frequency and type of use of computers in educational practice has been found in various studies, but one should be aware that many teachers have both innovative and traditionally important orientations.

In addition to studies about the relationship between teachers' pedagogical orientation and their ICT use, studies were conducted that focused on the relationship between teachers' professional engagement and their use of ICT. Drent and Meelissen (2008) studied factors that impacted innovative use of ICT by teacher educators. Innovative use of ICT in their study was defined as the use of a variety of open-ended ICT applications. Professional engagement was called 'personal entrepreneurship' and was defined as the number of professional contacts of a teacher educator. Drent and Meelissen found that personal entrepreneurship was the most important factor to explain innovative computer use by teacher educators. Riel and Becker (2008) reported findings of the Teaching Learning and Computing study (further abbreviated as the TLC study). They found a positive relation between professional engagement and teachers' pedagogical orientation. Professionally engaged teachers were holding a more constructivist orientation, which also showed off in their pedagogical practices. Riel and Becker also found that professionally engaged teachers used ICT more often and had their students use more different ICT applications compared with teachers who were less professionally engaged. Professional engagement in the TLC study was defined as a high score on three questions: frequency of six types of collaboration, frequency of three types of participation in communities of practice and teacher's involvement in six types of leadership activities. Next to the relation between pedagogical orientation and professional engagement, Riel and Becker also found that professionally engaged teachers had invested considerably more in their own professional development compared with the other teachers in the sample. The findings from Drent and Meelissen (2008) and Riel and Becker (2008) suggest that teacher leadership is an important factor in understanding innovative pedagogical use of ICT. Finally, many scholars (e.g. Pelgrum & Anderson 1999; Christensen & Knezek 2008) agree that teachers' ICT competencies are a basic condition for ICT use in education. Pelgrum and Anderson, in their international comparative study, concluded in 1999 that an increasing number of teachers have been introduced to basic ICT competencies but that most of them lack competencies related to the pedagogical use of ICT. Christensen and Knezek (2008) have shown that teachers who creatively used technology applications – which in this study would be called innovative pedagogical use of ICT – did not differ so much in their ICT competencies from teachers who used ICT for usual classroom tasks but held highly positive attitudes towards ICT. So although ICT competencies (basic and focused on pedagogy) might not differ for traditionally important or innovative use of ICT in the classroom, in this study, it was considered an important condition for the use of ICT in education.

In a secondary analysis of the data of SITES 2006 on pedagogical practices of extensive and non-extensive ICT-using science teachers, Voogt (2009) has shown that the traditionally important orientation to education is still dominant in the pedagogical practices of grade 8 science teachers. This finding concerned extensive ICT-using science teachers and non-extensive ICT-using science teachers. However, Voogt also found that science teachers who use ICT more extensively had a stronger focus on an innovative orientation to education compared with their non-extensive ICT-using colleagues, which was reflected in their perceptions about the impact of ICT on student outcomes and in the kind of pedagogical practices they used. This paper builds on these findings. In addition to differences in pedagogical practices of extensive and non-extensive ICT-using science teachers, differences in curriculum goals, in ICT competencies and in professional engagement were explored. The paper takes as a starting point that curriculum goals and pedagogical practices can be considered an indicator of teachers' pedagogical orientation. Teachers' pedagogical orientation in this view is a combination of beliefs (goals) and practice, which aligns with Guskey's (1986) view that beliefs and practice, though different, are closely related. In this paper, the pedagogical orientation of extensive and non-extensive ICT-using science teachers was compared. A distinction has been made between a pedagogical orientation that reflected curriculum goals and practices that were considered traditionally important versus goals and practices that had an innovative orientation and were considered important for lifelong learning in education. In addition to examining teachers' pedagogical orientation, we also analysed whether extensive and non-extensive ICT-using science teachers differed with respect to their ICT competencies and their professional engagement.

Methods

This study is a secondary analysis of teacher data from SITES 2006. The development of the teacher questionnaire as well as the sampling method used in SITES 2006 has been reported in Law *et al*. (2008a) and in Carstens and Pelgrum (2009). In this section, we therefore focus on the way indicators used in this study have been constructed and on the way extensive and non-extensive ICT-using science teachers were identified.

Instrumentation

Indicators based on questions of the SITES 2006 teacher questionnaire were constructed for the teachers' pedagogical orientation, the teachers' ICT competencies and the teachers' professional engagement. Table 2 provides an overview of the indicators that were constructed, the alpha reliabilities and some exemplary questions. Teachers' pedagogical orientation was based on two indicators: curriculum goals; and teaching and student practices (in short, also called pedagogical practices). A distinction was made in a pedagogical orientation that reflected traditionally important curriculum goals and pedagogical practices and a pedagogical orientation that reflected lifelong learning curriculum goals and pedagogical practices (see also Law & Chow 2008). In addition to the indicators for pedagogical orientation as presented in Table 2, an indicator was constructed for ICT-supported traditionally important teaching and learning practices by multiplying the average scale score for traditionally important teaching and learning practices with the average scale score of practices in which ICT was being used. In a similar way, an indicator for ICT-supported lifelong learning teaching and learning

Table 2. Overview of indicators, number of items in scale, exemplary survey items and alpha reliabilities.

	Number of items	Exemplary items	α
Pedagogical orientation			
Traditionally important curriculum goals	3	To improve students' performance in assessments and examinations To prepare students for upper secondary education	0.59
Traditionally important teacher & student practices	6	Assess students' learning through quizzes Students working on the same learning materials at the same pace and/or sequence	0.63
Lifelong learning curriculum goals	4	To foster students' collaborative and organizational skills for working in teams To individualize student learning experiences in order to address individual learning needs	0.74
Lifelong learning teacher & student practices	12	Help/advise students in exploratory and inquiry activities Students learning and/or working during lessons at their own pace	0.85
Information and communication technology (ICT) competencies			
General ICT competencies	8	I can email a file to a colleague I can use the Internet for online purchases and payments	0.90
Pedagogical ICT competencies	8	I can prepare lessons that involve the use of ICT I can use ICT for monitoring students' progress and evaluating learning outcomes	0.90
Professional engagement			
Professional development activities	7	Introductory course for Internet use and general applications Course on pedagogical issues related to integrating ICT into teaching and learning	0.80
Professional collaboration	4	I discuss problems that I experience at work with my colleagues I work with teachers in other schools on collaborative activities	0.58

practices was created. Two indicators were created to determine the teachers' ICT competencies, representing the teachers' basic ICT competencies and the teachers' competencies to use ICT in teaching and learning. The two indicators are self-reported data, reflecting the teachers' self-efficacy with respect to ICT use. Finally, two indicators were created to measure the teachers' professional engagement: involvement in ICT-related teacher professional development activities and collaboration with other teachers. The alpha reliabilities of the latter two indicators were <0.60, which is usually not acceptable (DeVellis 1991). However, according to Bos (2002), an alpha reliability >0.50 is acceptable for an exploratory study.

Respondents

To determine whether the grade 8 science teachers who were sampled to participate in the SITES 2006 survey[1] used ICT extensively, two questions were asked. In the first question, the teachers were asked whether they 'used ICT in teaching and learning activities in grade 8'. In the second question, the science teachers were asked to indicate whether they used ICT 'once a week or more in grade 8', 'extensively in grade 8 during a limited period in the year (e.g. in a project)' or 'none of the above'. The science teachers who answered affirmative to the first question were eligible for this study. The science teachers were considered to use ICT extensively when they had answered the second question with option 1 ('once a week or more'). Teachers' use of ICT in their teaching or learning was considered less extensive when they answered the second question with option 3 ('none of the above'). A weighting procedure was used to correct the different sample sizes of teachers in the countries participating in the study (Carstens & Pelgrum 2009). In this way, 1754 science teachers were considered extensive ICT-using science teachers and 1273 science teachers did use ICT but not very extensively. These teachers were used in the secondary analysis. Between the extensive ICT-using science teachers ($N = 1754$) and the non-extensive ICT-using science teachers ($N = 1273$), no significant differences were found with respect to age, gender and teaching experience. However, the two groups differed significantly with respect to educational level and home access to computers. The non-extensive ICT-using science teachers had a slightly higher educational level (effect size = 0.12) than the extensive ICT-using science teachers, while the extensive ICT-using science teachers had somewhat more frequent access to a computer at home than their non-extensive ICT using colleagues (effect size = 0.11).

Analysis

Next to means and standard deviations, *t*-tests were conducted to determine the differences between the extensive and the non-extensive ICT-using science teachers. In addition, effect sizes (Cohen's d) were calculated to get an indication of the magnitude of an effect. Cohen (1969) provided tentative benchmarks for the interpretation of effect sizes. He considers d = 0.2 a small, d = 0.5 a medium and d = 0.8 a large effect size.

Findings

Science teachers' pedagogical orientation

The teacher's pedagogical orientation was measured with two indicators: the curriculum goals they found important, and the teaching and learning practices (also called pedagogical practices) they applied (see also Table 2). For both indicators, a distinction was made between curriculum goals and pedagogical practices that were considered traditionally important and curriculum goals and pedagogical practices that reflected a lifelong learning orientation. To explore whether ICT was part of the teachers' pedagogical practices, a third indicator was used, which shows to what extent the teachers' pedagogical practices were supported with ICT. The findings (see Table 3) showed that the extensive and the non-extensive ICT-using science teachers considered both traditionally and lifelong learning curriculum goals important. The reason that the teachers found both traditional and lifelong learning goals important might be that, on the one hand, they saw the value of traditional goals as a means to support students in realizing their immediate personal goals, e.g. to prepare them for upper secondary education, but on the other hand, they also felt that they have to cope with changing requirements from society. The two groups differed significantly on both traditionally important and lifelong learning curriculum goals. The effect size was small (0.16) for traditional curriculum goals and in favour of the extensive ICT-using science teachers. A meaningful medium effect size (d = 0.56) with regard to curriculum goals that reflected an orientation on lifelong learning was found in favour of the extensive

Table 3. Comparison between extensive ($N = 1754$) and non-extensive ($N = 1273$) ICT (information and communication technology)-using science teachers with respect to pedagogical orientation.

Pedagogical orientation	Extensive ICT-using science teachers		Non-extensive ICT-using science teachers		*P*	Effect size[4]
	M	SD	M	SD		
Traditionally important						
Curriculum goals	3.39[1]	0.492	3.31	0.498	0.00[3]	0.16
Teaching and student practices	2.97[2]	0.461	2.97	0.467	0.98	0.00
ICT-supported teaching and learning practices	4.62[5]	1.146	3.89[5]	1.029	0.00	0.67
Lifelong learning						
Curriculum goals	3.42[1]	0.494	3.21	0.534	0.00[3]	0.56
Teaching and student practices	2.54[2]	0.508	2.24	0.448	0.00[3]	0.64
ICT-supported teaching and learning practices	3.75[5]	1.234	2.74[5]	0.826	0.00	0.96

[1] 1 = Not at all; 2 = a little; 3 = somewhat; 4 = very much.
[2] 1 = Never; 2 = sometimes; 3 = often; 4 = nearly always.
[3] significant at $\alpha = 0.01$.
[4] Cohen's d: 0.2 = small effect; 0.5 = medium effect; 0.8 = large effect.
[5] Scale varies between 1 and 8, 1 = not at all and 8 = very much.

ICT-using science teachers, which implied that the extensive ICT-using science teachers, more than their non-extensive ICT-using colleagues, found it important to comply with the changing requirements from society.

Similar findings were found for the second indicator, the pedagogical practices of extensive and non-extensive ICT using science teachers. Both traditionally important and lifelong learning practices were applied, and the lifelong learning practices were less often taking place than the traditionally important pedagogical practices. A closer inspection of the data showed that for the extensive ICT-using science teachers, the difference between traditionally important practices [Average (M) = 2.97, standard deviation (SD) = 0.461] and lifelong learning practices (M = 2.54, SD = 0.508) had a large effect size (d = 0.89); for the non-extensive ICT-using science teachers, the difference between traditionally important practices (M = 2.97, SD = 0.467) and lifelong learning practices (M = 2.24, SD = 0.448) was even larger, d = 1.60. When the extensive and the non-extensive ICT-using science teachers are compared, the two groups of teachers did not differ on traditionally important pedagogical practices, but they differed significantly with respect to pedagogical practices that reflected an orientation to lifelong learning with a medium^{+} effect size (d = 0.64).

It is obvious that ICT-supported teaching and learning practices were much more frequently found among the extensive ICT-using science teachers compared with their non-extensive ICT-using colleagues. The effect sizes between the two groups are medium^{+} (d = 0.67) for traditionally important practices but large^{+} (d = 0.96) for lifelong learning practices. Both groups used ICT more for traditionally important teaching practices than for lifelong learning teaching practices. The effect sizes were large: for the extensive ICT-using science teachers, the effect size was d = 0.73 in favour of ICT-supported teaching and learning practices; for non-extensive ICT-using science teachers, the effect size was even larger, d = 1.23.

To conclude, the results showed that traditionally important curriculum goals and practices were more common among the science teachers than lifelong learning curriculum goals and practices. In addition, ICT was more often used for traditionally important teaching and learning practices than for lifelong learning teaching and learning practices. However, particularly the extensive ICT-using science teachers attached more importance to curriculum goals and teaching and learning practices that reflected a lifelong learning orientation than their non-extensive ICT-using colleagues.

Teachers' ICT competencies

The extensive and the non-extensive ICT-using science teachers were also compared with respect to the ICT competency level they report to feel confident with. A distinction was made between basic ICT competencies and ICT competencies necessary for using ICT in teaching and learning. The findings are presented in Table 4. The results showed that the extensive ICT-using science teachers considered themselves significantly more confident in general and pedagogical ICT competencies compared with their non-extensive ICT using colleagues. The effect sizes were small–medium (d = 0.34) for general ICT competencies but fairly large (d = 0.71) for ICT competencies that were related to pedagogical use of ICT. It is noticeable that a relatively large

Table 4. Comparison between extensive (*N* = 1754) and non-extensive (*N* = 1273) ICT (information and communication technology)-using science teachers with respect to ICT competencies.

ICT competencies	Extensive ICT-using science teachers		Non-extensive ICT-using science teachers		*P*	Effect size[3]
	M	SD	M	SD		
General ICT competencies	3.42[1]	0.663	3.18	0.754	0.00[2]	0.34
Pedagogical ICT competencies	3.29[1]	0.623	2.82	0.711	0.00[2]	0.71

[1] 1 = Not at all; 2 = a little; 3 = somewhat; 4 = a lot.
[2] Significant at $\alpha = 0.01$.
[3] Cohen's d: 0.2 = small effect; 0.5 = medium effect; 0.8 = large effect.

proportion of the science teachers reported a rather high level of general ICT competencies. The frequency distribution shows that 30% of the extensive ICT-using science teachers and 19.1% of the non-extensive ICT-using science teachers felt very confident (score 4 = a lot) in accomplishing general ICT competencies.

Professional engagement

Professional engagement was measured with two indicators: the average number of professional development activities in which the teachers had participated or were willing to attend when possible and the average intensity of professional collaboration in which the teachers were involved. The results are presented in Table 5. Also here, the extensive ICT-using science teachers differed significantly from their non-extensive ICT-using colleagues on both indicators with small–medium effect size of, respectively, 0.35 for ICT-related professional development activities and 0.38 for intensity of professional collaboration.

A comparison of the different types of ICT-related professional development activities in which the 'extensive' and the 'non-extensive ICT-using' science teachers participated is presented in Table 6. The findings showed that the majority of the science teachers have taken an introduction course to ICT and that the extensive and the non-extensive ICT-using science teachers did not differ in this regard (d = 0.09). In each of the other professional development courses that were surveyed, less than half of the science teachers participated. The findings also showed that the extensive ICT-using science teachers participated in more ICT-related professional development activities than their non-extensive ICT-using colleagues and were more willing to participate in such a course if they had the opportunity.

Table 5. Comparison between extensive ($N = 1754$) and non-extensive ($N = 1273$) ICT (information and communication technology)-using science teachers with respect to intensity of professional engagement.

Professional engagement	Extensive ICT-using science teachers		Non-extensive ICT-using science teachers		P	Effect size[4]
	M	SD	M	SD		
ICT professional development activities	2.46[1]	0.523	2.29	0.507	0.00[3]	0.35
Professional collaboration	2.35[2]	0.582	2.14	0.503	0.00[3]	0.38

[1] 1 = No, I do not wish to attend; 2 = no, I would like to attend if available; 3 = yes, I have.
[2] 1 = Not at all; 2 = a little; 3 = somewhat; 4 = a lot.
[3] Significant at $\alpha = 0.01$.
[4] Cohen's d: 0.2 = small effect; 0.5 = medium effect; 0.8 = large effect.

Table 6. Comparison between extensive ($N = 1754$) and non-extensive ($N = 1273$) ICT (information and communication technology)-using science teachers of different types of ICT-related professional development activities (in % of teachers).

Professional development activities	Extensive ICT-using science teachers ($n = 1734$)		Non-extensive ICT-using science teachers		Effect size
	No, I would like to attend	Yes, I have	No, I would like to attend	Yes, I have	
Introduction course	17.7	66.3	20.0	61.4	0.09
Advanced course for applications	51.5	25.3	49.4	19.2	0.20
Advanced course for Internet use	57.4	27.3	56.7	20.4	0.23
Pedagogical course on ICT integration	52.7	36.7	60.0	24.9	0.25
Course on multimedia operations	62.6	24.3	62.3	16.6	0.26
Technical course	43.5	23.9	40.9	15.2	0.27
Subject-specific course on ICT use	61.5	29.7	66.0	17.1	0.36

Note: Cohen's d: 0.2 = small effect; 0.5 = medium effect; 0.8 = large effect.

Table 7. Comparison between extensive ($N = 1754$) and non-extensive ($N = 1273$) ICT (information and communication technology)-using science teachers of different types of professional collaboration.

Professional collaboration	Extensive ICT-using science teachers		Non-extensive ICT-using science teachers		Effect size[2]
	M	SD	M	SD	
Co-teach with colleagues	2.55[1]	0.978	2.29	0.991	0.26
Discuss problems with colleagues	3.29	0.737	3.21	0.733	0.11
Collaborate with teachers in other schools	2.28	1.032	1.96	0.904	0.33
Collaborate with teachers in other countries	1.29	0.675	1.12	0.422	0.30

[1]1 = not at all; 2 = a little; 3 = somewhat; 4 = a lot.
[2]Cohen's d: 0.2 = small effect; 0.5 = medium effect; 0.8 = large effect.

The differences between the two groups in the more specialized professional development courses were small+ (d varies between 0.20 and 0.36) but all in favour of the extensive ICT-using science teachers, which indicates that these teachers were more open to ICT-related professional development than their non-extensive ICT-using colleagues. Both groups seemed to be particularly interested in taking subject-specific (science) courses and were least interested in technical courses.

Also, different types of professional collaboration have been more closely examined. The results are presented in Table 7. The findings demonstrate that discussing problems with colleagues was the most frequent mode of collaboration. Both groups did not differ in the frequency they discussed problems with colleagues ($d = 0.11$). Relatively small effect sizes in favour of the extensive ICT-using science teachers were found for the other aspects of professional collaboration (d varies between 0.26 and 0.33). The findings showed that the extensive ICT-using science teachers more than their non-extensive ICT-using colleagues were co-teaching with others ($d = 0.26$) and collaborated with teachers in other schools ($d = 0.33$) and with teachers in other countries ($d = 0.30$). However, the high SDs also showed that co-teaching and collaboration with teachers in other schools differed a lot within both groups of science teachers.

Conclusion and discussion

In this paper, the extensive and the non-extensive ICT-using science teachers were compared with respect to their pedagogical orientation, their ICT competencies and their professional engagement. Pedagogical orientation was conceptualized as a combination of curriculum goals (beliefs) and pedagogical practices. A distinction was made between traditionally important curriculum goals and practices versus lifelong learning goals and practices. Traditionally important goals and practices reflected teaching and learning that is common in the industrial society and aligns with a teacher-centred view on teaching and learning, while lifelong learning goals and practices tried to comply teaching and learning with the needs of the knowledge society. These goals and practices were more aligned with a learner-centred or constructivist approach of teaching and learning. The findings showed that extensive ICT-using and non-extensive ICT-using science teachers considered curriculum goals and practices of both pedagogical orientations (traditionally important and lifelong learning) important. However, the extensive ICT-using science teachers had, compared with their non-extensive ICT-using colleagues, a stronger orientation towards lifelong learning as reflected in the curriculum goals they pursued and the pedagogical practices they applied in the classroom. It is obvious that extensive ICT-using science teachers in comparison with non-extensive ICT-using science teachers applied more ICT-supported pedagogical practices. The results showed that although the use of ICT to support teaching and learning practices were more frequently used for traditionally important pedagogical practices by both groups, extensive ICT-using science teachers applied ICT for lifelong learning practices much more than their non-extensive ICT-using colleagues. Based on the findings of this study, it can be concluded that frequency of ICT use and a pedagogical orientation that reflects lifelong learning goals and practices are positively related. Similar findings were found in the studies of Riel and Becker (2008) and Tondeur *et al*. (2008).

In addition to the relationship between frequency of ICT use in educational practice and pedagogical orientation, a positive relationship was found between frequency of ICT use and teachers' professional engagement. The results of this study demonstrated that extensive ICT-using science teachers tended to be more professionally engaged than non-extensive ICT-using science teachers. A closer inspection of the differences showed that extensive ICT-using science teachers in particular co-teach more often and collaborate more often with teachers from other schools. This finding concurs with the results reported by Riel and Becker (2008) and Drent and Meelissen (2008). A high level of collaboration with other teachers would characterize these teachers as a teacher professional (Riel & Becker 2008) or as a personal entrepreneur (Drent & Meelissen 2008). The finding that extensive ICT-using science teachers attended more ICT-related professional development activities also supports the results found by Riel and Becker. Finally, the results of the study showed that extensive and non-extensive ICT-using science teachers differ in their ICT competencies and their pedagogical ICT competencies in particular. This finding underlines the often expressed need for ICT-supported teacher professional development that is pedagogically oriented. A particularly interesting result in this respect is that extensive ICT-using science teachers have attended more subject-specific ICT courses. This finding supports the notion that teachers need technological pedagogical content knowledge (TPCK) (Koehler & Mishra 2008) to be able to frequently use ICT in educational practice. McCrory (2008) mentioned four elements critical for TPCK in the science domain: knowledge of science, knowledge of students' preconceptions, knowledge of science-specific pedagogy and knowledge of ICT. Webb (2008) argued that science teachers need to learn how to relate the affordances of specific ICT applications for science education, such as modeling, simulations and data logging devices, to students' alternative conceptions of specific science concepts in order to be able to incorporate the ICT applications in concrete learning activities. Voogt *et al*. (2009) found that science teachers who participated in a science-specific ICT professional development arrangement in which McCrory's and Webb's suggestions were integrated were able to plan and conduct ICT-supported science lessons but that more time was needed to incorporate these competencies in their daily routines. So science-specific ICT courses is a good start for science teachers to acquire TPCK, but science teachers also need time to build routines in the integration of ICT in their educational practice.

In this study, the term pedagogical orientation was conceptualized as a mixture of curriculum goals (beliefs) and pedagogical practices. This term was chosen on purpose to underline the close connection between educational beliefs and classroom practice (Guskey 1986; Calderhead 1996; Fullan 2007) and because of the available data in SITES 2006. For this reason, the importance teachers' attached to (traditionally important or lifelong) curriculum goals in connection with teachers' (ICT-supported) pedagogical practices were considered as an operationalization of teacher beliefs. One might argue that this is a poor operationalization of teacher beliefs. In their operationalization of teacher beliefs, Tondeur *et al*. (2008) used a mixture of opinions about teaching and learning and actual teaching practices. They made a distinction between 'traditional teaching' and 'constructivist teaching'. Niederhauser and Stoddart (2001) operationalized teacher beliefs in terms of instructional perspectives. They asked teachers to express their perceptions of effective uses of ICT in different (that is learner-centred or teacher-centred) instructional settings. These operationalizations are clearly more closely connected to actual practice than the intentions teachers' express in the curriculum goals they find important for their teaching. On the other hand, Ertmer and Park (2009) took a broader perspective. They used three components to measure teachers' beliefs about ICT: pedagogical beliefs about teaching and learning; self-efficacy beliefs about technology use; and beliefs about the value of computers for student learning. While the first operationalization is similar to the operationalizations of Tondeur *et al*. (2008) and Niederhauser and Stoddart (2001), the other two operationalizations are more related to measures of ICT competencies and attitudes towards ICT (see also Christensen & Knezek 2008). In this way, Ertmer underlines that teacher beliefs are not a one-dimensional construct.

The operationalization of pedagogical orientation in terms of traditionally important and lifelong learning goals and practices which was chosen for this study intended to emphasize that teacher beliefs are also the result of social cultural influences that affect teachers' personal experiences. This notion is present in the aforementioned operationalizations, but not explicitly addressed. Finally, the different operationalizations also show that teacher beliefs are not only a messy construct (Ertmer 2005), but are also measured in a messy way. Research on teacher beliefs on the integration of ICT would therefore benefit from a better operationalization of concepts.

This study has shown a positive relationship between frequency of ICT use and teachers' pedagogical orientation, their ICT competencies and their professional engagement. These findings may have implications for ICT leadership in schools. Dexter (2008) argued that ICT leadership needs to create a learning environment in the school to develop teachers' ICT skills. This study has shown that in such a learning environment, the focus needs to be on subject-oriented use of ICT, that teachers' pedagogical orientation needs to be taken serious and that teachers need to get opportunities for professional engagement.

The findings of this study are exploratory. Follow-up studies with the SITES database can be used to further explore models, such as linear regression and structural equation modeling, which could explain causal connections between innovative pedagogical use of ICT and teachers pedagogical orientation, teachers' professional engagement and their ICT competencies.

Note

[1]Data were collected from science teachers of 21 education systems who participated in the SITES 2006 study.

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