SCIENCE TEACHERS' ICT USE FROM A VIEWPOINT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPCK)

Satu Helppolainen & Maija Aksela
The Unit of Chemistry Teacher Education, Department of Chemistry, University of Helsinki

Abstract In order to develop science teachers' Technological Pedagogical Content Knowledge (TPCK), a better understanding of how teachers use ICT in classroom practice is needed. This paper examines Finnish chemistry teachers, knowledge, skills and beliefs on using ICT in education in comparison to other science teachers. The study shows that chemistry teachers have positive beliefs of using ICT and computers as a tool for teaching and learning. Teachers' earlier training in the use of ICT had increased their beliefs towards using ICT. The study shows that, in general, teachers have good *basic ICT skills*, but lack skills to integrate ICT into education, due to a lack of technological content knowledge (TCK) and technological pedagogical knowledge (TPK). The results show that teachers especially lack knowledge on subject-specific software, such as modelling software. The results suggest that chemistry teachers need more ICT-training from the viewpoint of TPK and TCK in order to help them get ideas and materials that can be directly applied to classroom practice, and to acquire experience to develop their own TPCK. The results give implications on how science teachers' in-service training can be developed.

Keywords Science teachers, chemistry teachers, teachers' technological knowledge, ICT use, ICT beliefs, ICT integration, ICT barriers, TPCK

1 Introduction

Teachers' professional development is a key for successful integration of information and communication technology (ICT) at school level. (Ertmer & Ottenbreit-Leftwich, 2010; Clarks & Hollingsworth, 2002; Pernaa & Aksela, 2009) In previous studies, Voogt (2010) and Rogers & Twidle (2014) found that teachers' participation in subject-specific ICT-training increased ICT integration in the classroom, which was supporting notification of the importance of Technological Pedagogical Content Knowledge (TPCK). In order to increase science teachers' TPCK, there is a need to increase understanding on science teachers' ICT use in classroom practice.

Based on Shulmans' (1986) concept of Pedagogical Content Knowledge (PCK), Mishra & Koehler (2006) introduced a concept of Technological Pedagogical Content Knowledge (TPCK). TPCK is complex knowledge how to use various technologies to teach, represent and facilitate knowledge creation of specific subject content (Chai, Koh & Tsai, 2013). TPCK consists of several domains of knowledge. Technological knowledge (TK) is continuously changing knowledge how to use various software and hardware. Pedagogical knowledge (PK) is knowledge of all processes of teaching and learning, and content knowledge (CK) is knowledge of a subject matter. PCK is knowledge of the pedagogies, teaching and learning processes relevant to learning and teaching a subject matter. TCK is knowledge about how technology is used to present essential contents of a subject matter. TPK is knowledge of technologies used in teaching and learning settings and knowledge how technology might change teaching. (Schulman, 1986; Mishra & Koehler, 2006; Koehler et al., 2007) TPCK is dynamic, integrative and transformative knowledge of technology, pedagogy and content of a subject matter needed for pedagogically meaningful integration of ICT in teaching. However, TPCK is not a tool but rather tacit knowledge (Mishra & Kohler, 2006; Koehler et al., 2007; Rogers & Twidle, 2014).

There are several challenges and barriers to overcome before ICT is used extensively in the classroom. One may think purchasing adequate equipment in schools is enough for the effective use of ICT. It might be a sufficient stimulus for some teachers but not for all. Integration of ICT requires enough hardware, Internet access, proper software, materials, training and support. This is called "*first-order barriers*" or "external barriers" (Ertmer, 1999). Additionally, other teachers' opposing beliefs are significant first-order barrier (Ertmer et al., 2012).

Goktas et al. (2013) studied possible barriers encountered by Turkish primary school teachers in ICT integration. The barriers were the first-order barriers which could be overcome e.g. allocating more budged. The first-order barriers might be overcome and teachers might have good ICT skills but use of ICT for teaching and learning purposes is hindered by teachers' own beliefs of its relevance. This is called "*second-order barriers*" or "internal barriers" (Ertmer, 1999; Ertmer et al., 2012).

Teachers often easily reject innovations which are inconsistent with their personal conceptions of teaching and learning (Pajares, 1992). Educational beliefs and orientations of teachers and students are stable and chancing them later is resisted. (Goktas et al., 2009; Juuti et al. 2009; Prestridge, 2012) However, positive results about teachers' changed attitudes have been gained after offering experiences in ICT integration into traditional teaching (Barak, 2007; Hennessy et al., 2005). Hence, diffusion of innovations need to be supported in the real context (e.g. Lavonen et al., 2006) and teachers need time to make changes (Ertmer & Ottenbreit-Leftwich, 2010). Thus, ICT integration from top to down usually is not successful.

Papanastasiou & Angeli (2008) observed in their studies that the computer use, even on personal level, might lead the integration of ICT in practice. Additionally, Paraskeva, Bouta & Papagianni (2008) and Tezci (2010) noticed teachers being experienced with computers have better self-efficacy and more positive attitudes toward technologies, and therefore, integrate more ICT in teaching than less experienced. Self-efficacy, in this content, is perceived as ability to incorporate ICT in the practice (Abbitt, 2011; Watson 2006). In addition, support from school seemed to be important for using ICT in teaching and learning settings. (Ayub, Barak & Ismail, 2012)

Teachers' constructivist-oriented pedagogical beliefs predict the integration of ICT in the classroom constructivist way. (Feng et al., 2014; Teo et al., 2008; Tondeur et al., 2008)

Teachers believing traditional teaching tend to use technology in traditional way in which teacher is a source of knowledge and students are passive recipients. (Teo et al., 2008) Lim & Chai (2008) refers several previous studies and claims that teachers' pedagogical beliefs need to be change from traditional to constructive prior to effective use of ICT for learning purposes. Prestridge (2012) found that teachers who were competent at using ICT were more confident in using ICT in the classroom. However, ICT might be used as a traditional, teacher-centered approach. Professional development is needed to help teachers to transform their practice.

The purpose of this paper is to show current knowledge of Finnish chemistry teachers' ICT skills and beliefs in comparison to other science teachers. The survey conducted included five sections which were demographical information, technological knowledge, ICT beliefs and self-efficacy, school's climate and barriers, need for in-service training and support for ICT-integration.

The data was gathered from a sample of 190 school teachers from primary to general upper secondary schools. The sample was 137 female and 53 male teachers of which chemistry teachers were 68 and 20, respectively. The largest age group was the age of 41-50 year. Teaching experience of over 20 years was the most common. Most of the teachers (n = 86) taught in secondary schools, 53 in primary schools, 66 in general upper secondary schools, of which two taught both youth and adults, and three only adults. Similarly, 20 teachers taught chemistry in primary school, 42 in secondary school, 19 in general upper secondary school for youth and one in general upper secondary school for youth and adults.

2 Teachers' technology knowledge

This section will examine teacher's knowledge of software and the frequency of the software use.

2.1 Software knowledge

The computer knowledge of teachers was analyzed using Likert scale 1-to-5 with response options of "I cannot use it", "I can use it to a small extent", "I can use it satisfactorily", "I can use it well" and "I can use it very well". When comparing the software knowledge of the chemistry teachers and the other teachers the non-parametric Mann-Whitney U-tests showed two statistically significant differences ($p < 0.01$), knowledge of modelling software ($z = -4.339$, $p = 0.001$) and programming languages ($z = -2.585$, $p = 0.010$). Additionally, there were three significant differences ($p < 0.05$) in knowledge of data logging ($z = -2.544$, $p = 0.011$), simulations ($z = -2.417$, $p = 0.016$) and e-mail ($z = -2.333$, $p = 0.020$).

Table 2. Teachers' software knowledge.

Teachers' estimations of their own software knowledge.

	Chemistry teachers (N88)		Other teachers (N102)	
Software	Mean	S.D.	Mean	S.D.
Word processing (e.g., Word)	4.42	0.656	4.26	0.703
Databases (e.g.. Access)	1.83	1.074	2.04	1.218
Spreadsheets (e.g., Excel)	3.57	0.944	3.49	1.132
Graphics (e.g., Paint, Photoshop)	3.01	1.000	3.04	1.125
Multimedia authoring software (e.g., HyperStudio)	2.63	1.054	2.70	1.106
Presentation software (e.g., PowerPoint)	4.01	0.903	3.77	1.033
Concept mapping (e.g., C-map tools)	2.00	1.145	1.93	1.119
Publishing software (e.g., Publisher)	1.77	1.014	2.03	1.316
Internet	4.36	0.698	4.31	0.703
Email	4.64	0.591	4.44	0.638
Webpage authoring software (e.g., FrontPage)	2.06	1.076	2.47	1.447
Programming languages (e.g., Java)	1.47	0.787	1.89	1.142
Modeling software (e.g., Spartan, Edumol)	1.74	1.140	1.18	0.651
Microworlds/Simulations (e.g., PhET)	1.90	1.390	1.43	1.039
Data logging	1.86	1.074	1.56	1.020

Scale: 1 "I cannot use it", 2 "I Can use it to a small extent", 3 " I can use it satisfactorily", 4 "I can use it well", 5 "I can use it very well". (Papanastasiou & Angeli, 2008)

When comparing the mean scores of software knowledge there were only slight distinction between the chemistry teachers and the other teachers (Table 2). All teachers had good knowledge (mean scores > 3) in *common software tools*, such as, word processing (mean scores for chemistry teachers 4.4 and for the others 4.3), spreadsheet (3.6 and 3.5), presentation tools (4.0 and 3.8) and graphics (3.0 and 3.0), in addition to, Internet (4.4 and 4.3) and email (4.6 and 4.4). Knowledge of *specialized software* was poor. The chemistry teachers were more experienced than the other teachers in *modelling* (1.7 and 1.2), *simulation* (1.9 and 1.4) and *data logging* (1.9 and 1.6). *Programming languages* (1.5 and 1.9), *publishing software* (1.8 and 2.0) and *databases* (1.8 and 2.0) were not well known. Cronbach's alpha was 0.887.

2.2 Frequency of software use

Frequency of software use for personal purposes was analyzed using Likert scale 1-to-5 with response options of *"Never", "Once or twice a semester", "Once or twice a month", "Once or twice a week"* and *"Almost every day"*. The frequency of software use between the chemistry teachers and the other teachers was almost identical. Except for the computer programming which was used more frequently by the other teachers causing the only significant difference ($z = -2.427$, $p = 0.015$) in the Mann-Whitney U-test. Cronbach's alpha was 0.797.

According the mean scores, word processing (mean scores for the chemistry teachers 4.2 and 4.2 for the others), Internet (4.9 and 4.9) and communication tools (5.0 and 4.9) were used almost daily (table 3). Computer games, spreadsheets, presentation tools, graphical applications and publishing tools were used on average less than weekly (mean scores < 3). Less than a few times in semester (mean scores < 2) were used concept mapping, multimedia, web-page software, programming, simulations, modelling, data logging and educational CD.

Table 3. Teachers estimated the frequency of following software for personal use.

	Chemistry teachers (N88)		Other teachers (N102)	
The used software	Mean	S.D.	Mean	S.D.
Process text (e.g., Word)	4.15	0.929	4.23	0.999
Play games	2.57	1.552	2.47	1.474
Prepare spreadsheets (e.g., Excel)	2.69	0.914	2.75	1.228
Create graphics (e.g., Paint)	2.36	1.106	2.54	1.204
Develop multimedia (e.g., HyperStudio)	1.64	0.807	1.72	0.988
Make presentations (e.g., PowerPoint)	2.81	1.240	2.55	1.277
Map concepts (e.g., c-map tools)	1.34	0.712	1.28	0.570
Publish materials (e.g., Publisher)	1.98	1.239	2.00	1.295
Communicate (e.g., email)	4.98	0.150	4.93	0.430
Access the Internet	4.87	0.398	4.89	0.424
Develop web pages (e.g., FrontPage)	1.53	0.853	1.78	1.171
Program the computer (e.g., Logo, C)	1.22	0.579	1.47	0.807
Model complex systems (e.g., Spartan)	1.11	0.355	1.14	0.569
Author microworlds/simulations	1.06	0.237	1.09	0.452
Data Logging	1.24	0.549	1.24	0.750
Use educational CD	1.57	0.884	1.64	1.097

Scale: 1 "Never", 2 "Once or twice a semester", 3 "Once or twice a month", 4 "Once or twice a week", 5 "Almost every day". (Papanastasiou & Angeli, 2008)

2.3 Barriers hindering integration of technology to pedagogy and contents

Next there will be explained teachers' (i) self-efficacy and beliefs about ICT in teaching, (ii) beliefs about ICT as a teaching and learning tool, and (iii) the first-order barriers for the use of ICT.

2.3.1 Self-efficacy and beliefs about ICT in teaching

The beliefs and self-efficacy about ... were studied with Likert scale 1-to-5 with the response options of *"Completely disagree", "Disagree", "Neutral", "Agree"* and *"Completely agree ".* The Mann-Whitney U-test showed three significant differences: *"The computer is a valuable* *tool for teacher"* (z = -1.979, p = 0.048), *"I can do what the computer can do equally as well"* (z = -1.964, p = 0.049) and *"I can teach my students how to make their own web pages"* (z = -2.510, p = 0.012).

Table 4. Teachers' self-confidence and computer attitudes.

	Chemistry teachers (N88)		Other teachers (N102)	
	Mean	S.D.	Mean	S.D.
I can select appropriate software to use in my teaching	3.83	1.116	3.63	1.116
I can use PowerPoint in my class	4.57	1.087	4.25	1.087
I can design technology-enhanced learning activities for my students	3.30	1.305	3.31	1.305
I can use email to communicate with my students	4.47	1.083	4.24	1.083
I can teach my students to select appropriate software to use in their projects	3.31	1.245	3.40	1.245
I can teach my students how to make their own web pages	1.92	1.602	2.54	1.602
I can use the Internet in my lessons to meet certain learning goals	3.98	0.994	4.04	0.994
The computer can help students understand concepts more easily	3.77	0.892	3.76	0.892
I feel comfortable with the idea of the computer as a tool in teaching and learning	4.40	0.781	4.30	0.806
The use of computers in teaching and learning stresses me out	2.65	1.263	2.83	1.203
If something goes wrong I will not know how to fix it	2.55	1.016	2.66	1.121
The idea of using a computer in teaching and learning makes me skeptical	2.01	1.000	2.12	1.163
The use of the computer as a learning tool excites me	3.93	0.920	3.83	0.945
The use of computers in teaching and learning scares me	1.81	1.049	1.91	1.045
The computer is a valuable tool for teachers	4.68	0.468	4.44	0.791
The computer will change the way I teach	4.09	0.737	3.97	0.789
I can do what the computer can do equally as well	2.59	0.905	2.81	0.887
The computer is not conducive to student learning because it is not easy to use	2.16	0.829	2.09	0.891
The computer helps students understand concepts in more effective ways	3.31	0.939	3.23	0.900
The computer helps students learn because it allows them to express their thinking in better and different ways	3.34	0.908	3.21	0.958
The computer helps teachers to teach in more effective ways	3.73	0.991	3.60	0.947
The computer is not conducive to good teaching because it creates technical problem	2.61	1.108	2.61	0.987

Scale: 1 "Completely disagree", 2 "Disagree", 3 "Neutral", 4 "Agree", 5 "Completely agree ".(Papanastasiou & Angeli, 2008)

According to the mean scores (Table 4), the chemistry teachers agreed more with "*computers are valuable tools for teachers*" (the mean scores 4.7 and 4.4), "*the computer changes the way of teaching*" (4.1 and 4.0), and "*helps to teach in more effective ways*" (3.7 and 3.6). The computers are regarded with no suspicion even though they were reported to cause various challenges and technical problems in the classroom. The use of the computers were not felt scaring (1.8 and 1.9) or stressing (2.7 and 2.8) but quite exiting (3.9 and 3.8). The teachers thought they can solve possible problems with software or hardware quite well: *"If something goes wrong I will not know how to fix it"* (2.6 and 2.7). Students were thought to learn and understand concepts more efficiently with the computers (3.3 and 3.2)

The teachers were confident in using ICT in teaching and learning settings. They were capable of selecting appropriate software to be used in teaching (the mean scores for the chemistry teachers 3.8 and for the others 3.6), planning technology-enhanced lessons (3.3 and 3.3) and using the Internet to attain certain learning goals (4.0 and 4.0). They were able to select appropriate software for students' projects (3.3 and 3.4), and to use PowerPoint in the classroom (4.6 and 4.3), but teaching to web pages making was poorly known (1.9 and 2.5). Cronbach's alpha was 0.504.

2.3.2 ICT as a teaching and learning tool

The teachers' beliefs about ICT as a teaching and learning tool were studied with eight statements using a scale *"Agree (with a score 1)", "Disagree (-1)", "Neither (0)"* based on the previous study of Wikan & Molster (2011).

In the Mann-Whitney U-test only one significant difference was found: *"ICT improves learners' presentations or assignments"* ($z = -2.055$, $p = 0.040$).

Table 5. Teachers' beliefs of ICT as a teaching and learning tool

	Chemistry teachers (N88)		Other teachers (N102)	
	Mean	S.D.	Mean	S.D.
ICT increases the ways of teaching and learning	0.90	0.305	0.88	0.353
ICT helps learners to find new information	0.80	0.483	0.75	0.501
ICT makes lesson diverse	0.88	0.333	0.78	0.480
ICT improves learners presentations/assignments	0.66	0.585	0.44	0.739
ICT increases motivation	0.45	0.642	0.40	0.601
ICT supports independent learning	0.40	0.653	0.45	0.591
ICT enhances subject learning	0.26	0.652	0.28	0.723
ICT supports collaboration	0.25	0.682	0.20	0.690
ICT makes working faster	0.19	0.771	0.15	0.837
ICT makes learners work harder	-0.09	0.721	0.03	0.710
ICT disturbs in pupils' concentration	-0.06	0.684	-0.15	0.737

Scale: 1 "Agree", -1 "Disagree", 0 "Neither". (Wikan & Molster, 2011)

According to the mean scores, the chemistry teachers regarded ICT as teaching and learning tool slightly more positively than the other teachers: *"ICT increases the ways of teaching and learning"* (mean scores for chemistry teachers >0.9 and <0.9 for the others) and *"ICT makes lesson diverse"* (0.9 and 0.8) (table 5). The teachers also thought *"ICT facilitates finding new information"* (>0.8 and <0.8). The chemistry teachers believed more than the other teachers that *"ICT improves learners' presentations and assignments"* (0.7 and 0.4) and *"ICT increases motivation"* (0.5 and 0.4) but slightly less that *"ICT supports independent learning"* (0.4 and 0.5). All teachers agreed less with *"ICT enhances subject learning", "ICT supports collaboration" and "ICT makes working faster"*. The chemistry teachers, somewhat, disagreed with "*ICT makes learners work harder*" and all teachers disagreed slightly with "*ICT disturbs in pupils' concentration*". Cronbach's alpha was 0.785.

2.3.3 First-order barriers

The possible first-order barriers hindering the effective ICT use were analyzed using Likert 1-to-5 scale with response options of "*Completely disagree*", "*Disagree*", "*Neutral*", "*Agree*", and "*Completely agree*". In the U-test no significant differences between the teacher groups were noticed. Based on the mean scores the barriers were quite similar to all teachers. The main barrier was lack of time, in particular, for the chemistry teachers (4.1 and 3.9) (Table 6). Optionally, teachers were able to add other barriers in the open-ended question. The qualitative responses were in line with the quantitative items.

> *"Lack of time, rush at work", "Courses full of contents", "Time, students cannot use devices, not enough time...", "No time for learning how to use hardware/software".*

Another notable first-order barrier for the chemistry teachers was lack of hardware (4.0 and 3.6).

> *"No proper hardware at home, No WLAN, no smart board, technical problems, frustrating!"*
>
> *"Lack of hardware"*
>
> *"Internet connections weak, slow, no connections..., Slow computers, Software not working"*
>
> *"Devices do not communicate", "Slowness of Internet and opening software"*

Furthermore, lack of appropriate software or materials (3.5 and 3.5) and instructional programs and course content (3.5 and 3.6) were significant barriers. Additionally, lack of in-service training (3.4 and 3.5) and lack of technical support (3.6 and 3.5) were regarded as insufficient. Cronbach's alpha was 0.789.

> *"Lack of knowledge and skills how to integrate ICT in learning", "Lack of good ideas", "Students incapable to utilize computers in learning purposes", "Software not suitable for all subjects (such as in mathematics)", "Lack of material", "Lack of training", "Lack of skills and knowledge", "Lack of motivation", "I am too lazy", "I'm not active", "I'm too slow to learn and I forget soon what I've learnt", "Slowness of technical help"*

Table 6. Barriers hindering effective ICT integration in the classroom practice.

	Chemistry teachers (N88)		Other teachers (N102)	
	Mean	S.D.	Mean	S.D.
Lack of appropriate software/materials	3.53	1.164	3.45	1.256
Lack of appropriate course content and instructional programs	3.51	1.135	3.56	1.157
Lack of basic knowledge/skills for ICTs	2.58	1.354	2.71	1.383
Lack of basic knowledge/skills for ICT integration	3.05	1.268	2.97	1.164
Lack of in-service training	3.44	1.276	3.37	1.242
Lack of hardware	3.95	1.231	3.59	1.381
Lack of technical support	3.55	1.240	3.45	1.347
Lack of time	4.14	1.008	3.89	1.052
Lack of appropriate administrative support	2.81	1.240	2.91	1.336

Scale: 1 "Completely disagree", 2 "Disagree", 3 "Neutral", 4 "Agree", 5 "Completely agree ". (Goktas et al., 2009)

Other teachers mentioned barriers were lack of money, behavior of pupils and lack of skills of colleagues.

> *"No money for buying techniques", "Problems in municipal economy", "Commercial software could not be bought"*
>
> *"Behavior of pupils", "Lack of skills and knowledge of other teachers, and therefore, no collaboration"*

2.4 Need for support and training

There it will be explained next (i) teacher's views of school's climate and support, (ii) teachers' views' of teaching approach and assignment type, (iii) teachers' need for in-service training and support:

2.4.1 School's climate and support

School's climate and support were studied using Likert scale 1-to-5 with response options of *"Completely disagree", "Disagree", "Neutral", "Agree"* and *"Completely agree"*. However, no significant results were noticed in the Mann-Whitney U-test. According to the mean scores, school's climate and support were good. The value of ICT in teaching and learning was well understood amongst the participants (the mean scores for the chemistry teachers were 3.5 and for the others 3.6) (Table 7). Cronbach's alpha was 0.823.

> *"I use ICT only if some additional values for teaching are obtained with it"*

The encouragement for integrating ICT in teaching and learning were good by the principals (3.6 and 3.7), ICT coordinators (3.3 and 3.3) and other teachers (3.5 and 3.3). The chemistry teachers shared ideas and encouraged each other slightly more than the other teachers (3.6 and 3.5) but ICT in the school curriculum was not frequently discussed (3.0 for the both groups).

Table 7. Teachers were asked to evaluate climate and support for ICT usage in their school.

	Chemistry teachers (N88)		Other teachers (N102)	
	Mean	S.D.	Mean	S.D.
Other teachers encourage me to integrate computers in teaching and learning	3.48	1.144	3.27	0.946
The ICT coordinator encourages me to integrate computers in teaching and learning	3.34	1.303	3.33	0.978
The principal encourages me to integrate computers in teaching and learning	3.55	1.231	3.66	0.980
I often exchange ideas about technology integration with other teachers	3.64	1.147	3.52	1.060
In faculty meetings, we frequently discuss the subject of integrating computers in the school curriculum	2.97	1.236	2.97	1.103
Teachers in my school are well informed about the value of computers in teaching and learning	3.48	0.971	3.55	0.929
A variety of computer software is available for use in my school	3.33	1.172	3.44	0.939
The technical support in my school is adequate	2.85	1.326	2.83	1.227
The instructional support in my school is adequate	2.82	1.199	2.91	1.082

Scale: 1 “Completely disagree”, 2 “Disagree”, 3 “Neutral”, 4 “Agree”, 5 “Completely agree “.(Papanastasiou & Angeli, 2008)

If desired, teachers were able to add comments on climate and support in the open-ended question. Peer support was regarded important.

> *“It’s enough to have one or a few eager teachers...”*
>
> *“Climate is generally supportive and teachers support each other”, “Lack of skills of other teachers, and therefore, e.g. no collaboration...”*

However, technical support were less adequate and financial resources were exiguous.

> *“There should be own technical support at school all the time”*
>
> *“ICT educators”*
>
> *“Because there are no devices, it’s impossible to use ICT regardless of climate...”*
>
> *“No money to buy software we would need”, “No resources to buy tablets”*
>
> *“Technical help”*

2.4.2 Teaching approach and assignment type

Teachers were asked to select which teaching style they prefer to student-centered or teacher-centered. Sixty-four percent (56) of the chemistry teachers and 63 % (64) of the other teachers preferred student-centered style. Similarly, they were asked to select which types of assignments they prefer to open-ended or closed. 53 % (47) of the chemistry teachers and 61 % (62) of the other teachers preferred open-ended exercises. However, some teachers commented it is impossible to select because the teaching style and the exercise type are dependent on a situation and a content.

2.4.3 The need for in-service training and support

Circa 78 % of all teachers and 75 % of the chemistry teachers had participated in ICT in-service training. Duration of the trainings ranged from a few hours to a few days. Forty of the teachers mentioned they had participated in training, without specifying the answers.

Table 8. Type of ICT in-service training teachers had participated.

Subject of training	Number of participants
Tablet/iPad	33
LMS (e.g. Moodle)	32
Geogebra (software in math)	17
Programing	8
Smart board	15
Office 365	5
Digital pedagogy	11
Digital materials/evaluation	16
Digital matriculation exams	9
Social media	8

Participation in ICT training was perceived to cause statistically significant differences in the U-tests with the statements *"The computer can help students understand concepts more easily"* ($z = -2.697$, $p = 0.007$), and *"ICT supports collaboration" ($z = -2.894$, $p = 0.004$).* Significant differences were found with *"The computer helps teachers to teach in more effective ways"* ($z = -2.361$, $p = 0.018$) and *"ICT supports independent learning" (z = -2,070, p = 0,038).* However, ICT training caused no meaningful differences of knowledge and the frequency of software use, barriers or school's climate and support (results not shown).

There were 120 answers in the open-ended question about need for ICT in-service training. Subject-specific ICT trainings were suggested in chemistry (n = 9), in physics (n= 3), in biology (n = 1) and in geography (n = 1).

> *"Data logging training",*
>
> *"Chemistry and ICT", "Mobile applications, suitable for secondary school, in which geography has the main role."*

Teachers needed training how to use ICT in mathematics (n = 21), and in programming (n = 11). The teachers in mathematics were lacking in high quality software suitable for the subject learning. Pen and paper often are more practical.

> *"Teaching mathematics with ICT", "Ideas how to use technology in the math classes 7-9", "Programs suitable for mathematics, e.g. how to replace pen and paper. Now, pen and paper is faster than writing calculations with a program. Thus, ICT slows but not improves. Some program give an answer, but it does not help to understand, how the answer was gained." "HTLM5-programming...", "Java-script programming..."*

Seven teachers desired ICT training from pedagogical point of view.

> *"Suitable pedagogical models, how to use tablets in teaching", "What added values ICT brings to pedagogy?"*

Training how to make e-materials and digital exams were desired (n = 14). The requirements of the upcoming digital matriculation exams cause the uncertainty and need for training (n = 7). The ideas for the tablet or iPad usage was also desired (n = 10). Some specified software e.g. multimedia tools were mentioned.

There were number of unspecified answers e.g.

> *"All kinds of training", "training for some applications", "I do not know, what kind of training I need, but the need is great!", "I don't need in-service training. I prefer to software, which really bring some added values for learning"*

Many of the teachers were in need of rather basic software training to get ideas or ready-made materials. Some of the participants expected differentiated training for experienced teachers.

> *"In-service trainings tends to be aimed for the fools"*

3 Conclusions and discussion

The chemistry teachers' ICT knowledge, skills, beliefs and usage were quite similar to other science teachers. However, there were some small distinctions between the teacher groups which might be caused by nature of chemistry and requirements of technological, pedagogical and content knowledge needed in the classroom practice.

3.1 Technological knowledge of chemistry teachers

Although technology is not the end, teachers need knowledge of technology itself and latest technological skills to develop their TPCK for effective ICT integration in the classroom. Similarly to previous studies of Papanastasiou & Angeli (2008) and Tezci (2010) software knowledge of Finnish chemistry teachers was divided into two groups: well-known common software applications and less-known specialized software applications. Although, knowledge of subject-specific applications caused significant differences between the chemistry teachers and the other teachers, technological knowledge of these applications were poorly known. Additionally, both knowledge and use of computer programing software caused significant difference between the teacher groups, though knowledge and skills of all teachers were poor.

The chemistry teachers used computers, at least for personal tasks, almost daily. The frequency of software use was divided into three groups: used almost daily, used less than a few times in month, and used hardly ever. This is in line with findings of Paraskeva et al., (2008) who observed that Creek teachers had moderate experience and one-sided use of applications.

Although, according to Ertmer & Ottenbreit-Leftwich (2010), technological knowledge itself is not enough for the effective use of ICT, Papanastasiou & Angeli (2008) noticed personal use of the computers increases the ICT integration in the classroom. Similar effect was observed here. The both teacher groups were capable of using the frequently used common software (e.g. PowerPoint or Internet) in the classroom to accomplish certain learning goals. However, the poorly known specialized software, e.g. web page making, could not be taught. According to Brun & Hinostroza (2014) advanced and complex pedagogical activities are usually less frequent and requires adequate professional development. Advanced pedagogical activities requires good TPCK of teachers. Teachers' pedagogical activities in the chemistry classroom need to be investigated more carefully from TPCK viewpoints.

3.2 The first-order barriers hindering ICT integration

Technological knowledge is not enough if teachers are uncertain of its use (Ertmer & Ottenbreit-Leftwich, 2010). In particular, the chemistry teachers perceived the computer as a valuable tool for teachers, and they could not do things as well as the computers, which caused significant differences in the U-tests. In chemistry e.g. data-logging, simulations and computer modelling are essential subjects, thus increasing teaching methods when used in the classroom. This may explain, why chemistry teachers regarded computers as valuable and important, and experienced lack of hardware as one of the main barriers.

The teachers' confidence and self-efficacy of using the common software was regarded high and difference between the teacher groups was minor based on the mean scores. This is consistent with the previous findings. Paraskeva & Angeli (2008) and Prestridge (2012) noticed teachers who use more technology are more competent and confident in using it but also more open for new ideas and more likely to use ICT in the classroom successfully. If teachers do not have self-confidence and self-efficacy of using ICT its integration is likely to be hindered (Watson, 2006). Hence, getting familiar with technologies teachers' positive attitudes toward ICT may be developed, followed by the increased ICT integration in the classroom. (Tezci, 2010) Development of TPCK requires experiences of ICT in the practice.

Prior to teach with technology teachers need to expand their knowledge of pedagogical practice (Watson, 2006). Beliefs are related to values regarded important, in particular, for learning outcome. If ICT supports achieving most important instructional goals teachers are likely to use it. (Ertmer et al., 2010) In this study the teachers had positive thoughts of ICT as learning tool. They believed technology is effective for learning outcome which helps to find new information, understand concepts better and develop thinking skills. On the other hand, they agreed with that ICT increases students' motivation and subject learning, and they agreed slightly with that ICT supports students' collaboration or independent learning. These beliefs are in the major role in student-centered teaching approach. Teachers' pedagogical beliefs are deeply-rooted and chancing them later is challenging. (Goktas et al., 2009; Juuti et al. 2009; Prestridge, 2012) Prior experiences of ICT have strong influence on teachers' beliefs, and therefore, ICT integration (Ertmer & Ottenbreit-Leftwich, 2010). Based on the previous studies (Feng et al., 2014; Teo et al., 2008; Tondeur et al., 2008) prior to use ICT meaningfully in the classroom teacher have to change teaching style to student-centered. In this study, especially the chemistry teachers believed ICT changes their teaching method and enriches the lessons. However, it is not known whether it means the change from teacher-centered to student-centered. Over 60 % of the teachers preferred student-centered teaching style, and furthermore, 53 % of the chemistry teachers and 61 % of the other teachers favored open-ended assignments. Though, some teachers reminded it is impossible to choose which one to prefer because it dependents on the content and the situation. This indicates they use diverse methods. Wikan & Molster (2011) noticed the teachers participated in the long-term ICT-training used more student-centered teaching style than teachers participated only in short-term trainings. Long-term ICT-training might be needed to give experience of better learning outcomes of student-centered methods to the chemistry teachers. Thus, positive experiences of better learning outcome might increase teachers' positive beliefs and integration of ICT in the practice strengthening teachers' TPCK.

Teachers' self-reported barriers here were not so much second-order barriers (own beliefs) but first-order barriers (lack of sufficient hardware, Internet access, proper software, materials, training and support) (Ertmer, 1999). The findings were similar to previous study of Pernaa & Aksela (2009), the chemistry teachers were lacking in time and hardware but also materials, course contents and instructional programs, although differences between the teacher groups were not statistically significant. Additionally, a few teacher in mentioned heavy course loads as a barrier. Particularly, the chemistry teachers did not regarded basic ICT knowledge as barrier but knowledge for ICT integration were perceived moderate barrier by the both teacher groups. The findings were quite similar to the study of Goktas et al., (2013) who studied Turkish primary school teachers. Although, heavy course loads were challenge in Turkey, as well, decreasing the loads would not be a leading enabler for ICT usage. Similar to Turkish teachers, Finnish teachers believed allocating more budged and peer support would be enablers. Therefore, insufficient use of ICT might be caused more by lack of equipment, and less by lack of TPCK.

As Tsai & Chai (2012) discussed, lack of teachers design thinking skills, called "*third-order barriers*", might be a remaining barrier after removing first- and second-order barriers. Design thinking skills are needed to use ICT in right time and right place regardless of environment, which requires highly advanced TPCK.

3.3 Support and training needed to develop TPCK

Almost all teachers had participated in some short-term ICT-training during their careers as teachers. Participation in ICT in-service training was noticed to increase positive beliefs of teaching and better learning outcome. Even the short training was found to influence on teachers' ICT beliefs favorably but not on knowledge or use of ICT. Interestingly, Wikan & Molster (2011) found teachers' participated in long-term ICT-training and professional development used ICT more in the classroom and were more confident and competent than those participated only a short-time training. In this case more investigations need to be done to make further conclusions.

Teachers wished to have in-service training in software and hardware use, which is important to gain sufficient technological knowledge. This is the first, but not sufficient, step toward effective ICT integration. If getting experience of technology itself only, teachers are less likely to incorporate it in practice (Ertmer & Ottenbreit-Leftwich, 2010; Rogers & Twidle, 2014). Many teachers did not have ideas or skills how to integrate ICT in the subject matter, indicating they need more training to gain technological content knowledge or technological pedagogical knowledge in curriculum context (Roger & Twidle, 2014). A few of the teachers wished to have ICT-training from pedagogical point of view, possibly indicating subconscious thoughts of TPCK. In-service teachers have existing pedagogical content knowledge, and therefore, ICT needs to be introduced in specific ways within specific content which support learning outcome of students. Teachers need to gain knowledge to be directly applied in the classroom. (Ertmer & Ottenbreit-Leftwich, 2010)

Some of the teachers could not even express what kinds of training they would need, probably indicating they would need fundamental experiences of subject- and content-specific ICT integration to gain more TPK and TCK needed to start building up their own TPCK. As Voogt (2010) observed subject-specific ICT training increased ICT integration and it is a good start for developing teachers' own TPCK.

Although, there were no significant differences between the teacher groups here, teachers experienced support from colleagues and schools were sufficient. And particularly, the chemistry exchanged ideas with colleagues. The supportive climate in the school is vital for successful ICT integration (Ayub, 2012). Collaborating and talking with other teachers, in addition to active learning and reflection were found to have effective contributions to successful ICT integration and changing teachers' beliefs (Rogers & Twidle, 2014).

The chemistry teachers' technological knowledge was restricted. They evaluated to have good basic ICT skills but they were lacking in skills needed for ICT integration indicating deficiency of TCK or TPK. The teachers had positive beliefs of using ICT in teaching and learning settings which still need to be strengthen with experiences of students' positive learning outcomes. However, they did not have enough hardware and time, which might are the main reasons for a limited integration of ICT hindering development of their TPCK. Nonetheless, chemistry teachers' pedagogical activity in the classroom needs to be investigated more detailed to gain more accurate and complete information of current situation of teachers' ICT usage and TPCK. ICT-training was found to increase positive beliefs of ICT. The need for support and training of chemistry teachers were similar to the other teachers. Chemistry teachers need ICT-training in collaboration to other teachers from the student-centered, TPK and TCK points of view to bridge all these components of knowledge to acquire their own TPCK.

References

Abbitt, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among preservice teachers. *Journal of Digital Learning in Teacher Education*, *27*(4), 134-143.

Ayub, A. M., Bakar, K. A., & Ismail, R. (2012). Relationships between school support, school facilities, ICT culture and mathematics teachers' attitudes towards ICT in teaching and learning. *AIP Conference Proceedings*, *1450*(1), 196-200. doi:10.1063/1.4724139

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and teacher education*, *18*(8), 947-967.

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *The Journal of the Learning sciences*, *11*(1), 105-121.

Ertmer, P. A. (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. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of research on Technology in Education*, *42*(3), 255-284.

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*(2), 423-435.

Feng, D., Ching Sing, C., Chin-Chung, T., & Min-Hsien, L. (2014). The Relationships among Chinese Practicing Teachers' Epistemic Beliefs, Pedagogical Beliefs and Their Beliefs about the Use of ICT. *Journal of Educational Technology & Society*, *17*(2), 245-256.

Goktas, Y., Gedik, N., & Baydas, O. (2013). Enablers and barriers to the use of ICT in primary schools in Turkey: A comparative study of 2005–2011. *Computers & Education*, *68*, 211-222.

Goktas, Y., Yildirim, S., & Yildirim, Z. (2009). Main Barriers and Possible Enablers of ICTs Integration into Pre-service Teacher Education Programs. *Educational Technology & Society*, *12*(1), 193-204.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: commitment, constraints, caution, and change. *Journal of curriculum studies*, *37*(2), 155-192.

Ilomaki, L. (2011). Does Gender Have a Role in ICT Among Finnish Teachers and Students? *Scandinavian Journal Of Educational Research*, *55*(3), 325-340. doi:10.1080/00313831.2011.576910

Juuti, K., Lavonen, J., Aksela, M. & Meisalo, V. (2009) Adoption of ICT in Science Education: A Case Study of Communication Channels in a Teachers' Professional Development Project. EURASIA Journal of Mathematics, Science & Technology Education, 5(2), 103-118.Barak 2007

Koehler, M. J., Mishra, P. & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. Computers & Education, 49(3), 740-762

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons. *British Journal of Educational Technology*, *39*(5), 807-828.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research*, *62*(3), 307-332.

Papanastasiou, E. C., & Angeli, C. (2008). Evaluating the Use of ICT in Education: Psychometric Properties of the Survey of Factors Affecting Teachers Teaching with Technology (SFA-T3). *Educational Technology & Society*, *11*(1), 69-86.

Paraskeva, F., Bouta, H., & Papagianni, A. (2008). Individual characteristics and computer self-efficacy in secondary education teachers to integrate technology in educational practice. *Computers & Education*, *50*(3), 1084-1091.

Pernaa, J., & Aksela, M. (2009). Chemistry teachers' and students' perceptions of practical work through different ICT learning environments. *Problems of Education in the 21st Century*, *16*, 80-88.

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education*, *58*(1), 449-458. doi:10.1016/j.compedu.2011.08.028

Rogers, L. & Twidle, J. (2013). *A pedagogical framework for developing innovative science teachers with ICT.*

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, 4-14.

Teo, T., Chai, C. S., Hung, D., & Lee, C. B. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education*, *36*(2), 163-174.

Tezci, E. (2010). Attitudes and knowledge level of teachers in ICT use: The case of Turkish teachers. *International Journal of Human Sciences*, *7*(2), 19-44.

Tsai, C. C., & Chai, C. S. (2012). The" third"-order barrier for technology-integration instruction: Implications for teacher education. *Australasian Journal of Educational Technology*, *28*(6).

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*(6), 2541-2553. doi:10.1016/j.chb.2008.02.020

Watson, G. R. (2006). Technology professional development: Long-term effects on teacher self-efficacy.

Voogt, J. (2010). Teacher factors associated with innovative curriculum goals and pedagogical practices: differences between extensive and non-extensive ICT-using science teachers. Journal Of Computer Assisted Learning, 26(6), 453-464.

Wikan, G., & Molster, T. (2011). Norwegian secondary school teachers and ICT. *European Journal of Teacher Education*, *34*(2), 209-218.