Chapter 17
Teachers' Views of Technological Pedagogical Content Knowledge: The Case of Compulsory Education Science in-Service Teachers

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Introduction

Several studies have shown that, when teachers use ICT, they do so in ways that preserve their existing teaching practices, or use ICT tools to search the Web for support material for producing notes or creating worksheets, or for circulating exercises and tests (Tzimogiannis and Komis 2004; Kenneth et al. 2005). It has also become clear that the classroom integration of ICT as a means of making teaching practice more explorative, participatory and co-operative often requires changes in traditional forms of teaching and professional development of teachers in their pedagogical use of ICT (Zhao et al. 2002; Tzimogiannis and Komis 2004; Kenneth et al. 2005; Bikos and Tzifopoulos 2011).

The knowledge that teachers need in order to be able to integrate ICT into the educational process is complex. It has to combine (scientific) content, technological means and educational theory, and if it is to affect their teaching practices it has to be functional. One widely used model that blends content, pedagogy and technologies in a system of interactions defined by these three parameters is the Technological Pedagogical Content Knowledge (TPACK) model (Mishra and Koehler 2006; So and Kim 2009; Doering et al. 2009; Alayyar et al. 2012). The basic components are knowledge of (scientific) Content (CK), Pedagogical Knowledge (PK), which embraces contemporary pedagogical theory and strategies, and Technological Knowledge (TK), which refers to features of technological environments.These three factors are interrelated and interact. As a result, they shape complex knowledge: that is, Pedagogical Content Knowledge (PCK), which

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among other things includes knowledge of strategies and representations that are suitable for teaching the subject, Technological Content Knowledge (TCK), which includes knowledge of the software packages and their possibilities, and Technological Pedagogical Content Knowledge (TPACK), which includes knowledge of how ICT can be used to support the planning and implementation of specific teaching strategies in the classroom, e.g. to encourage explorative or co-operative learning through the use of ICT. Mishra and Koehler (2006) have shown that teachers have to understand how the three components of TPACK are interrelated if these technologies are to play a real role in classroom practice.

In Greece, teacher's professional development (henceforth TPD) in the use of ICT in compulsory education known as B-Level (and we shall use this term hereafter for the sake of brevity) includes an integral approach to the pedagogical utilisation of ICT in science teaching. The programme is part of the broader, multiyear programme of PDT in the use of ICT that is being implemented, with the support of the Ministry of Education, by the "Diophantus" Computer Technology Institute under the supervision of a scientific committee. This is a two-part programme, with a total duration of ninety-six (96) hours (CTD 2007). It comprises a general part (18 h) and a special part (78 h), with teaching material for both parts, to be implemented by the instructors at each training centre as they see fit. The programme is carried out in special training centres established which have the necessary infrastructure. Each group of trainee teachers consists normally of 10–12 participants taught and guided in their works by one or two experienced certified instructors who have been educated in a special TPD programme.

The science programme is designed to stimulate the interest of the teachers, impart knowledge and skills, and encourage positive views and attitudes towards integrating ICT in science teaching. The material, and presumably therefore its utilisation in the training centres, applies elements of the TPACK model. For example, Pedagogical Content Knowledge (PCK) includes topics such as pupils' ideas about natural phenomena and concepts, pupils' cognitive difficulties and teaching strategies such as the constructive and the exploratory approach to school science (B-Level 2010). Technological Content Knowledge (TCK) covers, besides the basic approved ICT tools, such as Interactive Physics and Iridium VLab, matters relating to content transformation, such as the visualisation of concepts in specific technological environments and the representation, description and transformation of scientific concepts and processes. Technological Pedagogical Knowledge covers the gains from software and Internet applications, such as the use of ICT in the modelling of concepts. Technological Pedagogical Content Knowledge (TPACK) includes knowledge of how ICT can be used to support specific science teaching strategies, for example designing experimental procedures in virtual environments and promoting collaborative activities using Google docs, as well as theoretical knowledge about ICT in education, contemporary theories of learning, models integrating ICT into education, and the characteristics and handling of basic computer tools.

It has been shown that, as adults, teachers are ready to learn and develop new skills relating to their profession through involvement in the designing of genuine

learning activities, that is, activities that lead to classroom applications and are incorporated into classroom reality (Kalantzis and Bill 2010). Much of the special part of the programme focuses on designing activities, worksheets and innovative authentic teaching scenarios, which promote the development of TPACK by combining aspects of science teaching with the utilisation of ICT in thematic areas covering all branches of school science: Physics, Chemistry, Biology and Geography. The teachers are taught to analyse prepared scenarios from the accompanying B-Level material, design innovative activities and scenarios, e.g. developing learning activities with virtual laboratories and hypermedia applications for specific units of physics, chemistry or biology, develop appropriate teaching aims and design learning supports. In addition to the theoretical lessons, since 2010, the training centres have required in-service teachers to implement practical applications in the classroom, using the available activities and scenarios or composing new ones designed to make use of ICT. The total duration of this part of the programme is 42 h, which includes trainee support sessions at the training centres as well as the classroom applications. Design and classroom implementation are the main aim of in-service training.

The present research investigates how compulsory education science teachers who have had B-Level training see the programme and its benefits in terms of TPACK, and their own readiness to apply what they have learned in the classroom. More specifically, it looks at their views of the pedagogical and technological knowledge furnished by the programme, whether they feel themselves to be familiar with the environments and able to design scenarios using software programs, whether they can implement them in the classroom and whether the training was on the whole interesting.

Sample

The research was carried out with a total of 69 in-service compulsory education, physics, chemistry, biology and geography secondary science teachers who had B-Level training in seven (7) training centres in Northern Greece.

Tools

In the framework of applications of the programme in in-service teacher training centres, the researchers studied teachers' views of aspects of TPACK through written self-report questionnaires and interviews. The questionnaires contained closed, Likert-type questions to be answered on a scale of 1–5 (very little, little, average, much, very much). The content of the questions took into account other studies and proposed tools, the structure of the programme and the PE04 B-Level

material (Lee and Tsai 2010). In this study, we refer to a total of 11 questions, which are tabulated in the Results section.

(Cronbach's alpha is 0.793, Cohen and Manion 1997). Part I, containing Questions 1, 2 and 3 (Table 17.1), asks about teachers' views of the pedagogical technological knowledge furnished during the course: that is, the appropriateness of the theoretical knowledge for understanding principles of integrating ICT into the educational process, the usefulness of the educational material (texts, software, scenarios, bibliography and on-line resources) and the practical exercises with the software. Questions 4, 5 and 6 deal with Technological Pedagogical Content Knowledge: that is, information about integrated lesson planning incorporating ICT and how to apply this knowledge. In Part II, Questions 7 and 8 (Table 17.2) concern their Technological Knowledge, and specifically skills relating to software installation and solving technical problems. Questions 9 and 10 (Table 17.2) ask about aspects of their Technological Pedagogical Content Knowledge, and specifically how well prepared they think they are to design and implement teaching scenarios using software. Finally, Question 11 asks how interesting they found the training programme. Sampling took place towards the end of each programme. The questionnaires were completed anonymously in the presence of the researcher.

Table 17.1 Teachers' views as regards the benefits of the programme

	Very little, little (%)	Average (%)	Very much, much (%)	MV	SD
1. Did it provide you with appropriate theoretical knowledge for understanding the basic principles for integrating ICT into the educational process?	17	37.3	45.8	3.32	0.973
2. Did it provide you with useful educational material and software for implementing scenarios using software?	1.7	32.2	66.1	3.80	0.714
3. Did it provide you with practical training with the software?	13.6	16.9	69.5	3.71	0.892
4. Did it provide you with appropriate knowledge for designing scenarios using ICT?	5.1	30.5	64.4	3.73	0.762
5. Did it provide you with suitable support, during the programme, for implementing teaching activities and scenarios in the classroom?	13.6	20.3	66.1	3.73	0.944
6. Do you think that the activities and scenario applications you carried out in the classroom during the training course were important?	8.5	16.9	74.5	3.80	0.961

Table 17.2 Teachers' views concerning the integration of ICT (TPACK)

	Very little, Little (%)	Average (%)	Very much, Much (%)	MV	SD
7. Do you feel ready to install the educational software successfully on your school's computers?	20.4	25.4	54.2	3.46	1.10
8. Do you feel ready to solve possible technical problems with the operation of the educational software you have been taught?	45.7	32.2	22	2.63	1.12
9. Do you feel ready to design teaching scenarios using the software you have been trained on?	10.2	23.7	66.1	3.75	0.883
10. Do you feel ready to implement teaching scenarios using the software you were trained on?	11.9	33.9	54.3	3.53	0.838

We also conducted semi-structured personal interviews for a more in-depth investigation of the teachers' views. The interview questions were related to the questionnaire and provided clarifications of the answers given in it. The answers were transcribed, analysed and discussed by two researchers, for consensus on their meaning. A total of 59 questionnaires were completed, due to absences on the days they were distributed, and 8 interviews were conducted with a random sample of teachers of different subjects from different training centres.

Results

The questionnaire results are tabulated by frequency of answer, mean value and standard deviation, with the two negative and the two positive categories compressed into single ones to show the main tendencies. A summary of the answers to the corresponding interview questions is also given.

Teachers' Views as Regards the Benefits of the Programme

Most of the sample gave a positive response to Questions 2 and 3 on the questionnaire, concerning technological pedagogical knowledge, particularly with respect to the practical, hands-on work with software, that is, the technology they would be using in the classroom. The rest (16.9 and 32.2 %, respectively) answered average, and a small fraction recorded negative views. We observe that the teachers were comparatively less positive about the provision of theoretical knowledge

(Question 1), with 45.8 % declaring themselves satisfied or very satisfied; this question also had the highest number of average answers.

In order to get a better and more fully elaborated notion of these views, similar questions were asked in the interviews. It emerged that the theoretical part was presented in several cases in a traditional manner, in the training centres, with the use of PowerPoint by the instructors. When the participating teachers had some prior knowledge, this was followed by real dialogue and discussion. When this was not the case, the instructor merely presented the theoretical part and went on to the next unit, or gave the participants the material to study on their own. Their opinions show that the theoretical part was glossed over in favour of closer study of the software.

As regards the third question, the majority of the interviewees felt that they were helped by actually using the software, that they learned about software previously unknown to them and that they afterwards selected and used in the classroom software that had either been taught or selected from the Web during the course of their hands-on practical work.

Besides, we note that the majority of the teachers (64.5–74.5 %) replied positively to the next three questions (4, 5 and 6), most of the rest pointed average (16.9–30.5 %), and a few were negative. Notably, the classroom applications were the most appreciated element (74.5 %).

The answers to the interviewer's questions show that the teachers had indeed dealt with the use of software in the classroom and using worksheets, but what the instructors taught was the framework and methodology for integrating the software into their teaching. They declared, however, that the theoretical knowledge was of less help to them in designing material than the practical implementation, presentation and comments of scenarios by the instructors, which served as frameworks for designing their own scenarios.

Teachers' Views Regarding the Knowledge and Skills Needed for Integrating ICT into their Teaching (TPACK)

In Part II of the questionnaire, the answers to Question 7 show that the majority think that they have the know-how to install and operate the software taught. From the interviews, it became clear that while the teachers had used software in the classroom, they felt more confident about installing software after taking the course. The respondents were less confident about their ability to solve technical problems that might occur with the software on their school computers, as the quantitative results show, with only 22 % answering positively.

The percentage of positive answers was much higher for Questions 9 and 10 (59.2 and 64.3 %), which asked about two dimensions of TPACK. A percentage of the teachers (24–34 %) felt themselves to be moderately well prepared to design material, while a minority (10–12 %) rated their skills as limited.

The participants interviewed said that during the training programme, they had learned a lot about the framework and methodology for using prepared scenarios, using software to design new ones, and preparing better worksheets than they had been able to. They found the classroom implementations of activities and scenarios very helpful, which matches the results of the questionnaires. They all agreed, however, that they encountered difficulties with colleagues over their implementation in computer laboratories.

Interest in the Programme

A question concerning one of the pillars of adult education is whether a programme attracts the interest of prospective participants and engages them actively in it (Rogers 1999). The answers in our case are presented in Table 17.3 and show that most teachers found it very interesting; a small minority (11.9 %) expressed the opposite view.

The answers given in the interviews showed that in general the participants found the TDP programme interesting as it was structured, that is, with the theoretical part first, then the digital tools and the practical application last. When asked whether they would encourage or discourage their colleagues from attending a B-Level programme, they made it very clear that they would advise others to take the course, confirming both the importance of the training programme and the fact that they found it interesting.

In addition to the above, an initial analysis of possible considerable differences in the views of the groups of teachers from different training centres was carried out. Since the samples from each training centre were rather small, varying between nine and eleven teachers, we applied the nonparametric Kruskall–Wallis test for each question separately. Results showed that in most questions apart from three, there were not significant differences ($p > 0.5$). Differences were noted in Questions 1 and 4 (Table 17.1) and Question 5 (Table 17.2).

Discussion and Conclusions

This paper explores the views of compulsory education science teachers following a B-Level TDP course as regards aspects of the TPACK gained from the programme, whether they now believe themselves to be familiar with the digital environments

Table 17.3 Interest about the programme

	Very little, Little (%)	Average (%)	Very much, Much	MV	SD
11. Was it interesting?	11.9	27.1	61 %, 71	3.73	1.01

and with using software to design scenarios, and whether they can apply what they learned. The sample was drawn from a limited number of in-service teacher training centres in Northern Greece, which means that more general conclusions for B-Level professional development as a whole cannot be extrapolated from the results. On the other hand, the fact that the sample was drawn from a fair number of training centres, with potentially different methods of teaching the same training material and programme, should permit certain trends to emerge.

Within these limitations, most of the teachers were positive about aspects of the Technological Pedagogical Content Knowledge (TPACK) model provided by the programme. The results were much the same for their views of the skills they had acquired, save for technical knowledge. One particular important finding is that they found the programme interesting, which is a prerequisite for acceptance by an adult audience. The results of the questionnaires show minority varying between 17 and 33 % indicating a moderate degree of satisfaction with the TPACK gained from the programme, save for the practical exercises with the software, while the percentage of who were not satisfied was much smaller (8–13 %).

It is clear from the responses to the written questions as well as their interviews that the participants were relatively less positive about the provision of basic theoretical knowledge relating to the use of ICT, which means that they had some problems understanding and using it. The question was general, and the answers cannot show whether these views resulted from the teaching of the learning theories or other aspects of the general part. From the interviews, it appears likely that the theoretical content was taught in a traditional manner and not made interesting. Alternatively, lack of familiarity and basic pedagogical knowledge may have created comprehension problems for these secondary science teachers, or the widespread view that only science content (and not pedagogical theory) is important may have been an impediment. This issue requires further study and improvement. A second point concerns the skills necessary for solving technical problems, but this was not unexpected since B-Level does not focus on those matters. On the other hand, the teachers were very satisfied with the practical classroom exercises, which for several of them were the first time they had used ICT in a standard or innovative lesson in many subjects.

The average answers, which as a rule represented 20–30 % of the total for both knowledge gained and skills acquired, show that a segment of the group was not particularly satisfied and remains sceptical with regard to the ICT incorporation skills they acquired. From another point of view, however, in an adult education training programme where the audience is made up of teachers with very different backgrounds, it is not possible to fully satisfy the resulting multilevel range of needs. For example, this group of teachers included teachers with considerable experience in the use of ICT, or with post-graduate degrees, who considered themselves familiar with the theoretical part of the content of the B-Level programme or the software, and who by their own account would have preferred to take part in a programme with a more advanced ICT content, which in the present educational reality is not feasible.

Within the context of our research, we note in brief the following points about the features of the TPD programme that may have contributed to the positive views reported by the majority of the teachers. Mishra and Koehler (2006) claim that although the TPACK model appears to be a logical theoretical construct, simple in its conception, it is nonetheless hard for teachers to understand and even harder for them to apply effectively in educational practice. The designers of the B-Level material for compulsory education science teachers thought, as the package was being worked out, that explicit reference to modelling of the knowledge imparted in TPACK terms would probably create conceptual problems for teachers of that category in professional development training centres, who as a rule have little or no pedagogical knowledge since their basic professional training deals solely with the cognitive aspect. The B-Level material includes elements of TPACK, as we noted in the introduction. But, the TPACK model per se, its construction and terminology are not expressly mentioned in the material in the period covered by our research and consequently were presumably not taught by the instructors in the training centres. We think that this approach made it harder to engage the interest of the teachers and elicit a positive response from them.

Another characteristic of this programme is that the material and the proposed teaching processes are based on learning through designing and implementing applications in real situations, as we noted in the introduction. Learning through designing offers many ways of creating learning activities and situations and encourages varied higher-level thinking skills and cognitive processes: experiential, conceptual, analytical and application. In this context, the teacher becomes a reflective designer of teaching processes (Kalantzis and Bill 2010). In addition, as well as furnishing theoretical and practical knowledge, the programme also provided support for the application of the knowledge acquired. The instructors as a rule conducted many support sessions with groups of teachers to help them design classroom lessons.

Finally, we may note that though the purpose of this study was not to investigate in-depth variation in teachers' views studying in different training centres, the initial quantitative analysis showed that there were not considerable differences between the various groups in most questions. However, there were significant differences in questions concerning the benefits of the programme and specifically provision of appropriate theoretical knowledge for integrating ICT and for designing scenarios using ICT. It is possible that the educational process was variable in some centres concerning the treatment of theory and this is in line with the problems identified above in handling the theoretical aspects or the programme. Besides, there was probably differential support in the various groups for implementing teaching activities and scenarios in the classroom. Alternatively, the groups could consist of teachers with various experiences, knowledge and attitudes towards ICT implying that some teachers would need more support than average for applying ICT in classroom. This is an issue which needs further investigation.

In conclusion, and within the limits of our research, we feel that the positive response of the majority and the small size of the unsatisfied minority indicate that the structure and implementation of the B-Level TPD programme for compulsory

education science teachers promotes the development of their knowledge and skills while there is room for improvement of the programme, aiming always at high-quality professional development for teachers in the pedagogical use of ICT.

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