Chapter 14
Development of a Blended Learning Program and Its Pilot Implementation for Professional Development of Science Teachers

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Introduction

Blended learning approaches have been tried out in several areas, combining live educational activities implemented in traditional teaching environments with distance-learning activities supported by digital technologies and educational contexts (Gerbic 2011; Owston 2013). A number of studies have explored the effectiveness of the blended learning approaches that have been adopted and implemented mainly in higher education as well as their relation to distance learning and face to face (Ginns and Ellis 2007). Blended learning approaches can be at least, if not more, effective than wholly online systems and conventional face-to-face teaching (El-Deghaidy and Nouby 2008). In the area of teacher education, the knowledge that (science) teachers must have in order to integrate ICT in the educational process is complex. It has to combine scientific content with the technological and pedagogical aspects and be sufficiently functional to condition their teaching practices. Mishra and Koehler (2006) have suggested a widely used model in in-service teacher professional development (TPD) programs that combines content, pedagogy, and ICT through a complex system of interrelations defined by these three parameters, namely technological pedagogical content knowledge (TPACK) model (So and Kim 2009; Doering et al. 2009; Park et al. 2011). Concerning the integration of ICT in teaching, in-service teacher professional development (TPD) is often conducted in live, face-to-face sessions. There are valid reasons for turning to blended learning approaches, among them the possibility of providing professional development to a population of teachers that is either widely scattered or does not have access to training centers with appropriate infrastructures and giving opportunities for participants to experience the actual use

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of advanced LMS tools in authentic learning situations. Besides, blended learning programs have been successfully implemented for developing teachers' TPACK and were positively perceived by participating teachers to be (Alayyar et al. 2012) or in-service teachers (Owston et al. 2008).

There is no accepted model combining face-to-face and distance activities in a blended learning approach. The mix of the three forms of educational activity (face-to-face, synchronous, and asynchronous), the personal involvement of the students, and the learning procedure are determined by the aims. The design principles, the kind of learning objectives, and the profile of the students and instructors are the objects of study by researchers and educationists (Hofmann 2006). One important issue is whether the three forms of activities are structured in added on type, which implies that Web-based materials simply enrich face-to-face ones, or in an integral form, which implies taking advantage of the transformative value of the interactions between them (Garrison and Kanuka 2004). A second important issue is whether blended materials facilitate teachers to be actively learners being engaged in design and application of lessons and activities integrating ICT (Fozdar and Kumar 2007).

In Greece, teacher professional development (TPD) in the pedagogical exploitation of ICT, which is known as B-Level, and we shall use this term hereafter for the sake of brevity, is part of the broader multi-year TPD program in the knowledge and use of ICT that is being implemented, by the Computer Technology Institute "Diophantus" with the support of the Ministry of Education, under the supervision of a scientific committee (CTI 2007). The program, which has been in progress across Greece since 2007, until recently only in classical face-to-face sessions, has gradually begun to offer professional development possibilities to teachers who cannot easily get to a training center (e.g., in remote locations or with social, financial or mobility problems), with the pilot implementation of an innovative blended learning program called Meikto that combines face-to-face teaching with two forms of distance instruction, synchronous, and asynchronous. The blended learning program Meikto, called hereafter simply Meikto for the sake of brevity, is addressed to science, literature, mathematics, and informatics secondary teachers as well as to primary teachers.

In this context, the aim of the present paper was to outline and discuss the basic design principles and structure of the blended learning program Meikto, and we shall muse this term hereafter, for science teachers, present selected results from its pilot application concerning the views of the participating teachers on the distance activities, their knowledge gains from the program as well as their interest toward it.

Design of Meikto Blended Learning Program

The program for science teachers was designed on the basis of the following principles.

(i) Development of technological pedagogical content knowledge (TPACK) as a design framework and aim of the program

The TPACK basic elements are (scientific) content, which has to do with the subject to be taught, pedagogical knowledge, which covers contemporary theories of and approaches to education, and technological knowledge (TK), which concerns the technological environments and their relations with the particular (scientific) content. The interaction of these three interrelated factors has a synthetic result, yielding pedagogical content knowledge (PCK), which includes knowledge of strategies and representations that are suitable for teaching the particular subject, e.g., science, technological content knowledge (TCK), which includes familiarity with software and awareness of its possibilities, and technological pedagogical content knowledge (TPACK), which includes knowledge of how ICT can support the design and implementation of specific pedagogic strategies in the classroom, e.g., encouraging explorative or cooperative learning using ICT. Mishra and Koehler (2006) suggest that teachers have to understand the relations between the three components of TPACK if these technologies are to play a real role in classroom practice.

Meikto, and by presumption its applications, is based on the TPACK model and aims at developing teachers' relevant knowledge and skills but indirectly and without direct reference to the terms, as we have mentioned elsewhere (Psillos and Paraskevas 2014). For example, pedagogical content knowledge (PCK) includes topics such as students' ideas about natural phenomena and concepts; students' conceptual difficulties; constructive and inquiry approaches to school science. Technological knowledge (TK) covers aspects of using general tools, technological content knowledge (TCK) includes the basic approved software by the Ministry, for example Interactive Physics (http://www.design-simulation.com/ip/) and Iridium VLab (http://chemcollective.org/vlab_download), issues of content transformation such as visualizing concepts, representations, description, and transformation of scientific concepts and processes in specific technological environments. Technological pedagogical knowledge covers the gains from software and Web applications, such as the use of ICT in the modeling of scientific 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 or promoting geography investigations by taking advantage of Google Earth and interactive white board.

(ii) Integration of face-to-face and distance activities, synchronous and asynchronous

One thing that is important in a blended approach is coherence as regards the organization and interrelation of distance and face-to-face educational activities so that they are interconnected and meet the needs of the teachers (Vaughan 2007). This principle was applied in Meikto as is discussed in detail further on.

(iii) Learning through design

It has been shown that teachers, as adults, are eager to learn and develop new skills relating to their professional work through involvement in designing authentic learning activities, that is, activities that lead to classroom applications and are incorporated into classroom reality (Kalantzis and Bill 2010). Design and classroom implementation are, or should be, one main aim of teacher professional development in integrating ICT in teaching of science. Chai et al. (2013) in a recent review of empirical studies concerning TPACK concluded that all intervention studies "required the teachers to plan or design lessons for ICT integration as an important part of the course." In Meikto, much of the specific part, which concern science teaching, focuses on involving teachers in designing authentic innovative activities, worksheets, and teaching scenarios combining science teaching integrating ICT in thematic units that cover the whole spectrum of school sciences.

In Meikto, the teachers are taught by instructors in synchronous sessions; take part in asynchronous activities concerning the analysis of prepared scenarios and designing innovative activities, worksheets, and scenarios; and develop appropriate teaching aims and learning supports for the students. In addition to the theoretical lessons, they must implement practical applications in the classroom, using the available activities and scenarios or composing new ones with the help of the instructors in synchronous sessions, thus enhancing the development of their TPACK.

(iv) Enhancement of teachers' interest and active participation

In blended programs, such as this one, emphasis is given to having teachers participate and interact with one another, through the use of activities and support tools that will encourage them to be actively and continuously involved in the educational procedures using synchronous and asynchronous platforms to gradually constitute a learning community. Interest of teachers was prompted by contextualizing teaching of theories concerning, for example, contemporarily trends on science teaching such as inquiry-based learning as well as affordances of ICT for transforming scientific content and enhancing technology-mediated learning of science. Authentic problems were related to school curriculum and real student's difficulties. Besides, active construction of new knowledge was promoted by involving teachers continuously in individual and team tasks, their presentation on line to the whole group, discussion, and online feedback under the guidance of their instructors.

(v) Choice of a variety of appropriate tools and platforms

For the implementation of Meikto, we used the Moodle e-Learning platform (moodle.org) and supplementary tools to distribute the educational material and provide support for the asynchronous element of the model. For the implementation of the online sessions, we used Blackboard Collaborate (http://www.blackboard.com), a platform that provides tools for synchronous e-Learning/virtual classrooms, such as videoconferencing, application sharing, whiteboard, chat, and online voting. As appropriate, participants in the program could also use distance-learning support software (e.g., TeamViewer) or other distance communications software (e.g., Skype).

(vi) Provision and support for the teachers

The typical application of Meikto is carried out in a group of science teachers consisting normally of 10–12 participants spread out in a wide area who are taught and guided in their works by one or two experienced certified instructors and supported by one technician. For the face-to-face meetings, all participants have to travel and meet in special training centers (USE), which have the necessary infrastructure and provide technical and administrative support to the group.

Structure of Meikto Blended Learning Program

The material for Meikto was based on the material that was already used in the face-to-face program (B-Level 2010) but which was reorganized, adapted, and enriched so that the teachers could work with it with minimal assistance from the instructors and take advantage of the benefits of face-to-face and e-Learning. Each week includes a face-to-face or Blackboard-mediated synchronous session and asynchronous activities, using Moodle, which in principle should correspond to a roughly 3-h workload. The synchronous sessions were recorded and were immediately available so that teachers could review points and absentees could observe them. The asynchronous activities carried out by the participants individually or in teams included studying the teaching material or completing short exercises and tasks, designing and producing activities and worksheets.

All the educational material is stored on the Moodle platform and has been organized into weeks. Meikto has a total duration of (96) h. It has a two-part structure, with a general part (18 h) and a specific part (78 h), plus additional supported classroom applications totaling 48 h (CIT 2007). The program covers a total of 24 weeks, corresponding to 96 teaching hours plus additional supported classroom applications totaling 48 h. Week 1, in the beginning, weeks 7–8, in the middle, and week 24, at the end, are implemented in face-to-face sessions in which the teachers familiarize themselves with the material; new topics are introduced, and instructors and teachers discuss and reflect on the distance activities.

A brief description of the structure of the material appears in the introduction to the space, the "In-service TPD material: texts and software" file, from which the teachers can download the teaching material for each part. Figure 14.1 presents the initial page translated from Greek of the program for science teachers as uploaded to Moodle. Participants can download materials and tasks for each of the week separately right from the introductory space in the lines 1–24. The introduction to each week contains its title, learning objectives, and a brief description of its content. Each session consists of a title specifying the kind of session (face-to-face,

Fig. 14.1 Home page of the blended model for science teachers

synchronous, or asynchronous), the support material, and the suggested teaching approach, with guidelines for the instructor and the teachers for carrying out the activities, and links relating to the teaching material. The rest of the introductory page contains information about the program, rules to be followed, access to forum for discussion and access to virtual rooms.

Much of the specific part of the program as well as classroom applications facilitated collaborative learning on the part of the teachers through the required designing of innovative authentic teaching scenarios, which promote the development of TPACK by combining contemporarily approaches to science teaching such as inquiry with the utilization of ICT in thematic areas covering all branches of school science: physics, chemistry, biology, and geography (Maeng et al. 2013). The teachers were guided to navigate in the synchronous tasks focusing on familiarizing them with affordances of complex software, to analyze prepared scenarios from the accompanying material, design for example learning activities in chemistry with virtual laboratories such as iridium and hypermedia applications in biology for the circulatory system. They developed appropriate teaching objectives and designed student learning scaffolds via digital affordances such real time graphing in virtual laboratories. Coordination of the three forms of activities, face-to-face, synchronous, and asynchronous, was promoted by continuity and conceptual coherence of the on task work embedded in the distance sessions (Keengwe and Kang 2012). More specifically, these sessions included assigning of tasks to the teachers which started work at a synchronous session continued via asynchronous activities uploaded their work and/or presented it in the next synchronous session. The teachers studied the material on Moodle, uploaded and posted their work—individual or group scenarios—on Moodle and delivered virtual presentation to the whole group at the beginning of each synchronous session via Blackboard.

Pilot Research

(a) Sample and tools

The research was carried out with 20 secondary education science teachers, who participated in the pilot implementation of the blended model at two training centers during the winter of 2014. The researchers monitored their interest and their views as regards the appropriateness of the sessions, aspects of TPACK, and the role of ICT in the educational process, via written questionnaire. The questionnaire contained closed, Likert-type questions to be answered on a scale of 1–5 (very little, little, average, much, very much) as well as some open ones. For the development of the question relevant studies and proposed tools were taken into account (Lee and Tsai 2010). Content validity was established by two professors and two experienced instructors who carried out close examination of the structure of the program and the substance of the materials. In the present paper, we focus on questions regarding the interest demonstrated by the teachers, the knowledge and skills furnished and their views on the forms of the activities. Cronbach's alpha of the closed questions presented in this paper was 0.914 which is very satisfactory. The questionnaires were completed by the teachers using Survey Monkey. In addition to Likert-type questions, there was space for the teachers to express in free open format their perceptions about the program and its elements.

(b) Results

(i) Teachers' interest and participation

The focus of studies in blended programs is the interest and perseverance of the teachers and their continuous involvement in the suggested activities. In the pilot programs, there was only a single withdrawal, which occurred for personal reasons. The participants were actively involved both during the synchronous sessions, as attested by the recordings of their work and in carrying out the asynchronous activities, as attested by uploading of their tasks, which had to be posted and discussed at the next synchronous session.

When asked at the end of the program whether the program was interesting, 18 out of 19 answered positively or very positively, with only one giving an intermediate ranking. Besides, the teachers after experience of both face-to-face and distance sessions were asked if they would prefer face-to-face training; the preference (13 out of 19) was clear for the blended model. Only 3 participants would favor face-to-face TPD program instead of the blended one and 3 others were undecided, which confirms the appeal of the blended model to these subjects. In the open question concerning the reasons for such preference, they argued that the blended approach saved time and money, was convenient concerning timing, was an innovative intensive experience, and was feasible to attend. These results were corroborated by the teachers' comments. As one teacher puts it:

> (I would not prefer to be trained in a face to face program) I think that our "forced" familiarization with α Blackboard, Moodle, Virtual Box and the software by ourselves for making the e-presentations is the best education for understanding these tools.

(ii) Teachers' views of the sessions and their combination

At the end, the teachers were asked to rate the appropriateness of the activities in the synchronous sessions; 16 out of 19 rated them much or very much. The responses to another similar question concerning the asynchronous activities were in the majority also positive, with 14 out of 19 responding much or very much. The teachers were also asked to rate the appropriateness of the combination of face-to-face, synchronous, and asynchronous sessions; 18 out of 19 rated much or very much the overall mix. It is characteristic that only one of the teachers rated the combination of the three forms as only moderately satisfactory. In their free comments in the questionnaire, the teachers noted that the combination was appropriate. For example:

> … It was ok. Distance (synchronous) sessions are necessary because of time, space and traveling cost. Hopefully they are combined with asynchronous activities where you have peace and take as much time as you nee. In the face to face (sessions) live feeling is added which is missing in the distance sessions.

We may also note that several teachers mentioned that the sessions were intensive particularly at the beginning of the program and that the workload for the asynchronous activities exceeded the estimated three hours on task.

(iii) Teachers' views of the knowledge furnished by the blended model

At the end of the program, the teachers were asked whether the program provided them with what they needed to design activities and scenarios using software. The response was overwhelmingly positive, with 19 out of 19 responding much or very much to the question. Similarly, the response was overwhelmingly positive, with 19 out of 19 responding much and very much, concerning the provision of appropriate theory for employing ICT in their science teaching. Besides, they were asked whether the program provided them with adequate support along the way for their classroom implementation of innovative teaching activities/scenarios. The response was also positive 16 out of 19 teachers rating much and very much. Concerning the practical exercise with the taught software, 16 teachers rated much and very much while 3 rated average. In the open question for their overall experience, they argued that they learned about new software, how to use it in their teaching, how to design scenarios and innovative activities and experience up-to-date platforms. In a similar line were teachers' written comments. For example:

> … Certainly, yes it helped me a lot.. I did not know what was about. It was new for me. I just knew the software but I had never done a scenario. Where to rely upon in making a scenario

Conclusions

This paper discusses in brief the design principles, structure, and pilot implementation of a blended learning program called Meikto for science teacher professional development in the use of ICT in Greece. The sample of the pilot study was small, and only selected results are presented which allow us to draw cautious conclusions.

Overall, Meikto managed to draw the interest and active involvement of the teachers though it was demanding involving understanding of high complex knowledge, development of practical skills, and their interrelation. Most teachers were very positive about what they had gained from the program in relation to aspects of TPACK concerning the design, use, and integration of ICT in science teaching. We consider that one possible reason for such positive response by the teachers was that they were prompted continuously to be actively engaged in collaborative design of authentic activities and lessons involving integration of new ICT software and tools aiming at improving teaching of scientific topics. Besides, one feature of Meikto was that teaching practice was an integral part of this program, during which the teachers tried out the ICT-based innovative activities and lessons, which they had designed, in their own classrooms. In other words, teachers learned and taught with ICT and not simply about ICT. We take this as meaning that the implementation of Meikto did not fall short in its benefits for these dimensions of TPACK as well as in supporting classroom implementation. Such interpretation of the results is in line with reports in the literature about intervention studies concerning teachers' TPACK development which more or less required the teachers to plan or design lessons for ICT integration as an important part of the course (Chai et al. 2013).

Another feature of Meikto was the integration of face-to-face, synchronous, and asynchronous sessions, which was positively perceived the teachers for their professional development. As mentioned in the introduction of this paper, effective blended models have a transformative value taking advantage of both the richness of oral conversation and the thoughtful peaceful constructive writing of asynchronous fulfillment of assigned tasks (Garrison and Kanuka 2004). In face-to-face and synchronous sessions, the teachers were involved in rich conversations with their classmates and their instructors, for example in criticizing the suggested lessons plans which were assigned to and prepared by various teams within their group. There was a conceptual coherence and continuity between the tasks in the synchronous sessions and the tasks they had to fulfill in the asynchronous assignments almost every week (Berger et al. 2008). Although several tasks were intensive, particularly the asynchronous ones requiring some times more than the expected three hours workload to complete, intellectual involvement, and thoughtful reflection in carrying out the asynchronous tasks was complementary to rich and divergent exchanges in the synchronous sessions, was strong and motivating for the teachers. Blended learning is largely learner centered and features technology-mediated learning which focuses on knowledge construction, authentic activities, and social interaction (Gerbic 2011). We consider that by their nature the integration of well-designed face-to-face, synchronous, and asynchronous activities enhance constructive work, and ownership of the tasks to be fulfilled.

Provision of support in blended models is an important issue. The support the teachers received for the classroom implementation of activities and scenarios was provided through distant guidance and feedback synchronous and asynchronous (Alayyar et al. 2012). We consider that the positive response of the teachers in the relevant item of the questionnaire means that instructor support for classroom applications can be provided effectively not only face to face but online too. Having said this we also consider that the success of the pilot implementation was influenced by the properly trained instructors, whose role will be the subject of another study.

Meikto seeks to exploit the advantages of face-to-face teaching conducted in classrooms or laboratories and those of synchronous or asynchronous distance learning, and to avoid their problems (Gerbic 2011; Keengwe and Kang 2012). Taking into account the complexity of the TPACK knowledge which is the object of B-Level professional development program, the above initial results are encouraging for the acceptance and outcomes of Meikto. However, the workload of synchronous sessions and even more the asynchronous activities should be reduced. We may cautiously note, taking into account the differences between these two studies, that the results from the face-to-face version of the B-Level program, which are reported in another study in this volume show that teachers' perceptions of

Meikto are at least as positive as and even more positive than the face-to-face implementation (Psillos and Paraskevas 2014). The implementation of the nation-wide phase of the program, which is in progress, will contribute to extending professional development of (science) teachers concerning the integration of ICT who would have been excluded from it without the wide application of the blended model, as noted in the introduction to this article.

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