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Educational scenarios with ICT: an operational design and implementation framework

Vassilis Komis,
Department of Educational Sciences & Early Childhood
Education, University of Patras
Greece
komis@upatras.gr

Aggeliki Tzavara
Department of Educational Sciences & Early Childhood
Education, University of Patras
Greece
tzavara@upatras.gr

Thierry Karsenti
Faculty of Education
University of Montreal
Canada
thierry.karsenti@umontreal.ca

Simon Collin
Faculty of Education
University of Quebec in Montreal
Canada
collin.simon@uqam.ca

Stéphanie Simard
Faculty of Education
University of Montreal
Canada
simarst@uqtr.ca

Abstract: This paper proposes a framework for designing educational scenarios that incorporate ICT as a guide for prospective and practicing teachers. The design and implementation framework for educational scenarios integrates ICT into the pedagogical problematic according to contemporary learning theories. Based on principles of science teaching, the framework draws on the main components of the TPACK framework. We provide theoretical support for the model and its basic components, and we examine its implementation by prospective and practicing preschool teachers.

Introduction

Today's information and communication technologies (ICT) have enormous potential to provide opportunities for redefining objectives and teaching frameworks in the education system. For many years, the teaching and learning process was based on approaches that emphasized the transmission of information and the modification of behavior (behavioral approaches). Our framework adopts a very "technical" perspective on educational implementations: what matters are clear and functional definitions of teaching and learning goals as well as the imperative need to assess them ([Depover et al, 2007](#)).

However, many researchers believe that computerized tools cannot support the educational process in a meaningful way unless we can fully grasp how students build their knowledge in subject areas (constructivism). Thus, the learning process occurs as learners discover and construct concepts and rules through an active, individual knowledge creation process. The main critics of the traditional constructivist approaches point to cultural and social influences on cognitive development, in line with the sociocultural view of learning, which is based on the theories of Bruner (Bruner, 1997) and particularly the Soviet psychological school (Vygotsky, 1978). Against this background, we argue that thinking is developed through collaborative interactions between children and adults, with an emphasis on the roles of scaffolding (Harel, 1991, Nardi, 1996) and adult mediation in the learning process.

Based on these assumptions, the integration of ICT into education should be designed according to a clear theoretical framework that uses the affordances of technologies to improve educational practice and develop new ways of teaching subjects (Dimitracopoulou & Komis, 2005). Therefore, it is particularly important to educate prospective teachers and properly train practicing ones in this competency. But what skills do teachers need in order to effectively integrate ICT into their teaching practice? How can this knowledge be applied in real classrooms, and what are the best processes for classroom implementation?

This paper describes an operational model for the design and implementation of educational scenarios that incorporate ICT. Our model, which is adapted from the Technological Pedagogical Content Knowledge (TPACK) theoretical framework, is called the Technological Teaching Content Knowledge (TTCK) framework. Drawing on design-based research (DBR) methods, this model was implemented in a series of case studies involving both prospective and practicing teachers. Some first results are presented and discussed below.

The TPACK framework proposed by Mishra and Koehler (2006) provides a theoretical model for effective teaching using ICT. It takes into account the complexity of teaching and learning, and it recognizes the importance of technology in our daily lives (Niess, 2005, Mishra & Koehler, 2008, Angeli & Valanides, 2009). A review of the literature shows that many studies have called for further clarification of TPACK, giving rise to new, expanded, or modified models (Jang & Chen, 2010, Jimoyiannis, 2010, Lee & Tsai, 2009, Hammond & Manfra, 2009, So & Kim, 2009, Aggeli & Valanides, 2005, 2009). Accordingly, we have adapted the TPACK framework to construct the TTCK framework (Fig. 1), which emphasizes both school content and teaching knowledge concerning this content.

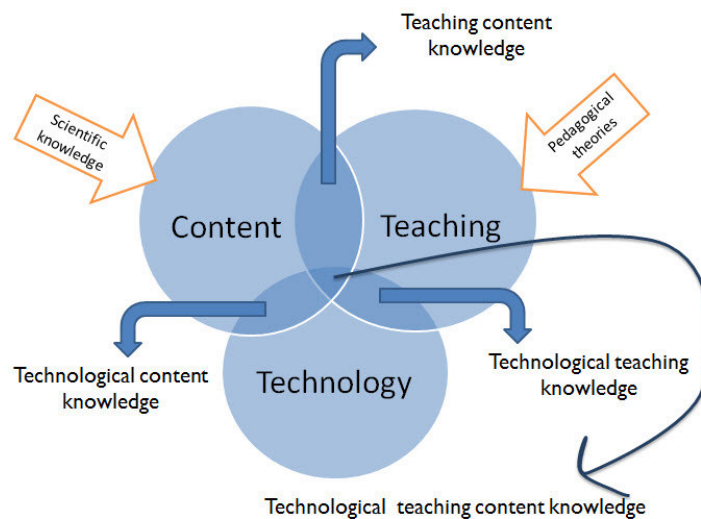


Figure 1: Technological teaching content knowledge

In our proposed model, teaching, content knowledge (or the content of a subject area as described in the curriculum), and technological knowledge constitute one system, where each component operates in close relation to the others. The TTCK framework delineates the essential knowledge that prospective preschool educators need in order to effectively implement ICT into their everyday teaching practice. It also establishes how the teaching defines the implementation of ICT in relation to content.

Both the TPACK and the TTCK framework are macroscopic frameworks for ICT integration into the educational process, and hence they do not provide a workable model for the design of everyday teaching practices. Traditional instructional design models include the ADDIE, the PIE, the ASSURE, and the like (Reiser & Dempsey, 2012). By instructional design we mean a methodology for designing and evaluating lessons, similar to the design process for other products. In fact, the ADDIE, the PIE, and the ASSURE models were meant to do exactly that. The novelty of our approach lies in the further refinement of the model into specific activities within a comprehensive instructional process and a detailed description of how technology may be integrated into the activities.

Our overall goal was to develop and document a theoretical model for designing ICT-integrated educational scenarios based on the TTCK theoretical framework. Here, the term “educational scenario” refers to a set of teaching activities that integrate ICT. The model and the data obtained from a first application are then presented.

Presentation of the design framework for ICT- integrated educational scenarios

An educational or teaching scenario that integrates ICT describes the teaching activities and the tools used (abstract tools such as schemata or software and/or physical tools such as special artifacts), which constitute both the starting point for the teaching and learning activities and the framework within which they will take place. The scenario therefore refers to both educators and students. It involves the application of effective teaching strategies in the aim of achieving learning objectives through the use of an appropriate computerized environment (educational software or other materials). In most cases, the scenario targets the teaching and learning of one or more main concepts in a curriculum subject area. The scenario may also address concepts that belong to different subject areas, in an interdisciplinary perspective, or it may target concepts beyond the curriculum.

An educational scenario includes instructions for teachers, the theoretical framework for each problem addressed, the materials required for implementation, activity sheets for students, and possibly other materials (e.g., software, lesson plans). An educational scenario is therefore implemented as a series of teaching activities. The scenario is a complete instructional intervention: it encompasses specific objectives, goals, the consideration of potential learning problems, and the implementation process, including appropriate activities and teaching strategies, assessment procedures, and so forth.

To design an educational scenario based on modern concepts of knowledge and learning, four main components must be included, as follows:

A) A contemporary pedagogical approach (constructivism and sociocultural theory):

- Identify the potential range and variety of tools and services offered by ICT, and in particular their affordances in the educational process.
- Use qualitative criteria for choosing appropriate educational software.

B) Appropriate content and structure:

- Relate the scenario to learning objects (e.g., sciences, mathematics, language) and to specific curriculum areas where ICT can be implemented as a cognitive tool.
- Choose scenarios that are developmentally appropriate for the students’ cognitive level.

C) Contemporary teaching methods. Educational scenarios should not only be facilitated by the use of ICT in the teaching and learning process, they should also foster and promote new, alternative forms of teaching that are more compatible with modern pedagogical and teaching theories and ICT uses. More specifically, scenarios should support and promote the transition:

- From direct and/or traditional teaching methods to group teaching and collaborative learning; and from teacher-centered teaching, where ICT are used as regulatory tools, to learner-centered teaching, where ICT are used as cognitive tools;
- From the lecture as a teaching method to exploratory and discovery methods;
- From a passive classroom to a mobilized classroom, through active student participation, communication between students, and authentic activities;
- From assessing students’ results based on a single final test to assessments based on a variety of processes and products.

D) Appropriate teaching strategies:

- Exploratory learning and discovery in authentic learning situations (for all subjects);
- Activities that promote problem solving, decision making and the development of critical thinking (for all subjects);
- Activities that foster symbolic expression, communication, and information search (for appropriate objects, e.g., language, written expression);
- Activities that promote investigation and information searches, for a wide range of data;
- Modeling activities and real-world situations;
- Developing collaborative problem-solving skills;
- Developing knowledge transfer skills.

Design phases for an ICT- integrated educational scenario

Based on the above-mentioned theoretical principles, the design of ICT- integrated educational scenarios is a pedagogical activity which, according to the TTCK theoretical model, requires knowledge of 1) the subject matter, 2) the teaching of the subject matter, 3) pedagogical and psychological theories of teaching and learning, and 4) the technology to be used, and in particular, the added value that the technology can bring to the teaching and learning experience. Designing an educational scenario involves seven distinct phases, which are usually closely interrelated and interacting (Fig. 2):

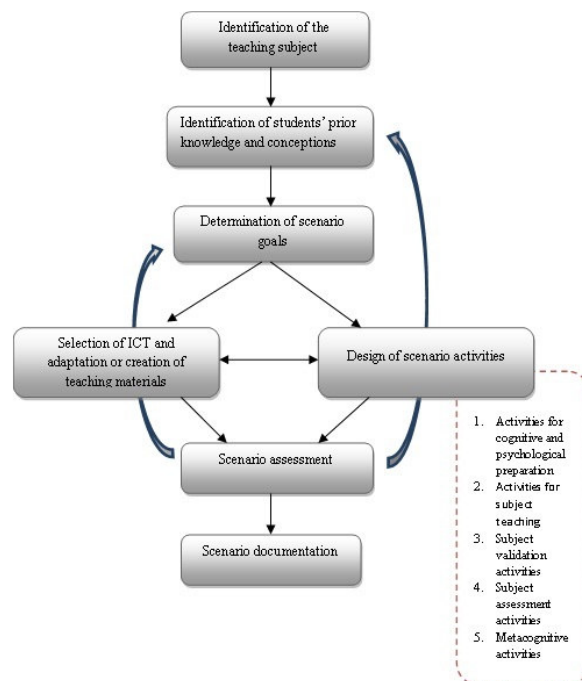


Figure 2: Different phases in the design of ICT- integrated educational scenarios

- A) The teaching subject of the educational scenario, including the title, level (preschool, early school, or grade school), subject areas involved, prerequisite cognitive skills, etc.
- B) Identification of the children's prior knowledge and any potential problems with their cognitive skills in terms of the subject area. At this point, the children's ideas, perceptions, representations, prior knowledge, and potential errors or cognitive problems regarding the teaching subject of the scenario are extensively discussed.
- C) The teaching objectives of the educational scenario (in relation to the subject matter, use of ICT, and the learning process).
- D) The teaching materials for the scenario and the required infrastructure.

E) The management of the teaching process, including the appropriate activities to implement the scenario in the classroom (teaching approaches and strategies, exploitation of the added value of ICT in the learning process, worksheets, etc.). This appears to be the most crucial phase, as discussed below.

F) Assessment and potential implications of the scenario.

G) Scenario documentation (comments, teachers' instructions, suggestions for potential extensions of the scenario, references, etc.).

These phases are largely interdependent, and are not necessarily followed in strict succession, although they are implemented according to a logical progression. For example, the teaching object is defined before the objectives, the teaching materials correspond with the goals, and the implementation activities of the scenario are largely developed in parallel. Alternative concepts along with previous ideas and representations can also be incorporated into the implementation activities, which are meant to reconstruct students' previous ideas and remodel their representations of the subject matter.

Designing implementation activities – Phase E

Phase E is the most crucial phase of the educational scenario, as this is where all the required classroom procedures for teachers and students are defined so as to achieve the scenario goals. In addition, this phase highlights why it is advisable for technology to be integrated into the teaching and learning process, according to the TTCK theoretical model.

Both the theoretical and methodological approach of the scenario (learning theories and teaching situations) must be determined in this phase, as well as the classroom organization, the teacher's role, the teaching approaches and strategies using ICT, and other teaching materials.

An educational scenario is implemented as a set of classroom activities. The usual activities are worksheets, which largely relate to the objectives. The sequence of the activities follows a common teaching design structure, which is independent of the potential use of technology. At this point, it is critical to identify specific activities that can benefit from a computerized environment and its comparative advantages over traditional teaching techniques.

These activities may be divided into at least five different categories:

A) Activities for cognitive and psychological preparation, assessment, and identification of prior knowledge, representations, and cognitive problems: These initial activities allow psychological and cognitive preparation and facilitate the establishment of an appropriate emotional atmosphere in the classroom. They also motivate the children and introduce the aim and objectives of the lesson. In addition, they allow assessing the children's prior knowledge, detecting cognitive problems, and identifying the children's representations.

B) Activities for teaching the subject area: These activities usually constitute the main portion of the scenario, because it is here that the target knowledge is introduced and most of the activities for the acquisition and construction of knowledge and skills are developed. Here, and in conjunction with the knowledge validation phase (see below), prior knowledge is reinforced, students' erroneous perceptions and concepts are corrected, representations are reconstructed, and an appropriate framework for conceptual change is proposed.

C) Subject area validation activities: Validation activities (for understanding and integrating new knowledge) usually involve teaching strategies similar to those used for teaching activities. They can include questions and answers, practical problem solving, and transfer of the acquired knowledge to specific situations.

D) Subject area assessment activities: Even though assessment is integral to the scenario implementation, the activities are examined in detail in the F phase, which consists of a general assessment.

E) Metacognitive activities. Metacognitive activities are also integral to the educational scenario, but they take place both inside and outside the classroom. They usually involve a cross-examination and comparison of the children's acquired knowledge with their prior knowledge and perceptions.

The scenario activities generally determine the form and content of the worksheets that are given to the students for classroom work. Each activity features one or more teaching strategies or teaching techniques.

Implementation of the design framework for ICT- integrated educational scenarios

This section describes how the proposed design framework was applied in order to design educational scenarios using a design-based research (DBR) approach in a series of case studies. The first results of this implementation with both prospective and practicing teachers are presented. The case studies had a twofold purpose: 1) to demonstrate, using a design-based approach, the applicability of the model, and potentially to make further adjustments; and 2) to examine potential differences between the two participant groups (prospective and practicing teachers).

The first group comprised 70 students enrolled in a preschool education program at the University of Patras. Their courses addressed the implementation of ICT into education. Specifically, three studies were conducted over three semesters with students enrolled in the following courses: 1) 30 third-year students enrolled in two different spring semesters, taking “Teaching of Informatics and ICT;” and 2) 40 third-year students enrolled in a winter semester, taking “Pedagogical activities with (and for) computers in preschool and early school age.”

The second group comprised practicing teachers who were trained in ICT integration into the educational process under a large-scale training program called “Training teachers in the use of ICT in the Teaching Process” supported by the Ministry of Education of Greece. These training programs targeted teachers in primary and secondary schools so that they could acquire knowledge and skills in the pedagogical use of ICT in teaching subjects. Here, we present the results of 135 preschool teachers who participated in two training sessions. Both groups applied the proposed design model and were asked to produce a final educational scenario incorporating ICT.

We now examine the scenarios produced by the two target groups (prospective and practicing teachers). The scenarios were analyzed according to the effectiveness of the implementation, categorized into three main attributes: a) completeness of TTCK implementation, b) completeness of design phase implementation, and c) appropriateness of ICT integration into the teaching strategies used for activities designed in phase E of the educational scenario. The analysis was performed using NVivo software, and the initial results are presented below.

A. Scenario design by prospective teachers

The analysis of the implementation of the proposed model by prospective teachers taking the university courses revealed that they had some problems implementing TTCK (Tzavara et al, 2012, Georgoutsou et al, 2012) Specifically, they appeared to have understood the framework in broad terms: they integrated the three main conceptual areas of TTCK, and in particular, they incorporated the notions of technological knowledge and teaching knowledge into their scenario designs. However, they had difficulty combining these notions into a fully realized TTCK conceptual framework.

With respect to implementing the key phases of the design model, they appeared to follow the steps and to have fully understood the flexibility involved as well as the need for feedback between the individual phases. Furthermore, the delineation of specific phases and content appears to have facilitated the design of the scenarios, because it allowed visualizing in advance the overall structure required to develop appropriate activities.

Each scenario incorporated the learning theories on which it was based. The analysis also revealed the types of teaching strategies used in designing the teaching activities (Phase C).

Behaviorism was the main learning theory underlying the scenarios, even though there were attempts to incorporate constructivist elements as well. For their teaching strategies, they also used behaviorist teaching strategies (practice and exercises, providing information), constructivist strategies (experimentation, problem solving), and sociocultural strategies (collaborative activities). As for the type of teaching help they proposed, guidance was the most predominant. However, to a large extent, they advocated asking the children questions as a way to support and guide their learning. Finally, in their activity design, they showed a preference for open software. In most cases, however, the activities were based mainly on behaviorist principles. The affordances of the software were therefore not fully exploited, thus mitigating the potential added value. Nevertheless, in many other cases, they used open software with a constructivist and/or sociocultural approach. In these cases, the software features were better exploited, which would result in a more active engagement of the students with the activities.

B. Scenario design by practicing teachers

Practicing teachers, during their training in ICT integration into education, also had problems implementing the TTCK theoretical framework into their scenarios. They appeared to have understood and implemented the

content knowledge quite well, but were uncertain about the technological and teaching knowledge and how to combine them properly.

The results on the implementation of the design phases of the educational scenarios are similar to those for the prospective teachers. The proposed structure was completely followed, and unlike the prospective teachers, they attempted to enrich it in light of their teaching experience.

A surprising finding is that practicing teachers also used behaviorist learning theories to inform most of their scenarios. At the same time, some teachers made an effort to change their teacher-centered approach to a more student-centered approach, through authentic exploration, discovery, and knowledge construction. They preferred production software (e.g., word processing and drawing), concept mapping, and—probably because their scenarios addressed preschool students—drawing software. ICT were used mainly as teaching media, and less as cognitive tools. Moreover, ICT were incorporated more for teaching and validation than for assessment activities.

Conclusions

In an effort to contribute to the development of new, enhanced, or modified theoretical models for the implementation of ICT into education, and in conjunction with the development of science teaching, this paper proposed a theoretical model called the Technological Teaching Content Knowledge (TTCK) framework. It was motivated by the need for primary school teachers to design appropriate pedagogical activities that incorporate ICT, and it was developed based on the TPACK model. Based on TTCK, a design model was developed in the aim of providing a framework for the integration of ICT into everyday teaching practice. Using a design-based research approach, the proposed model was examined in a series of case studies involving two target groups: prospective and practicing teachers of preschool education.

So far, the analysis of the results shows that the proposed design and implementation model can be used by both participant groups. A detailed analysis of the scenarios they developed demonstrates the model's applicability as a design framework. It also raises a number of interesting issues that should be taken into account in the design of university courses and training programs for the integration of ICT into teaching practice. First, it is important to note the lack of TTCK development in the participants' designs of educational scenarios. Whereas most of the participants understood and successfully implemented the three main conceptual areas of TTCK, they did not fully exploit the central notion of their combination and interrelation. Therefore, there appears to be a need for greater emphasis on the development of this notion.

Another important finding is related to several aspects of TTCK. The educational scenarios showed that prospective teachers had a better understanding of technological and teaching knowledge (probably due to the related courses they took at university), whereas practicing teachers were more familiar with content knowledge, probably thanks to their practical experience. Finally, it appears to be much easier to design behaviorist scenarios and activities and to integrate different types of educational software, even the more open-ended ones, than to design constructivist scenarios and activities.

Based on these results, we may conclude that, in designing educational scenarios, greater emphasis should be placed on activities that promote constructivist and sociocultural learning approaches and on integrating the appropriate educational software to facilitate this.

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