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Teaching competencies for technology integration in the classroom

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Abstract There is growing interest in the integration of technology into the classroom. A range of initiatives have been launched to develop in-service teacher training processes that will strengthen this integration. In the present paper, we systematize the findings of a large selection of studies on this topic, focusing on domains and competencies linked to teacher training propositions for technology integration. Our main result is the presentation of six such domains that have been proposed in the existing literature: instrumental/technological, pedagogical/curricular, didactic/methodological, evaluative/investigative, communicational/relational and personal/attitudinal. A set of teaching competencies for each domain is also identified. These domains and competencies together form the bases for creating a technology integration training model.

Keywords teacher training, teaching competencies, technology in the classroom, technology transfer, training domains.

Introduction

The process of integrating technology into classroom work has emerged as a significant focus of study in educational research. Interest in this trend has been motivated by the growing number of technology projects implemented in schools.

Investigative findings concur in emphasizing the complexity of the phenomenon. For researchers such as Hernández-Ramos (2005), technology integration should be defined not simply as a question of access but rather as a tool both for improving educators' professional productivity and promoting student learning.

Within this analytical framework, studies such as Lawless and Pellegrino (2007) assert that even though in-service training is officially recognized as a fundamental vehicle for teachers to develop more effective instruction using new technologies in teaching and learning processes, technology has not been sufficiently incorporated into school work and has yet to be properly articulated with other classroom teaching activities.

In other words, although in-service training programmes have contributed to the growing understanding of the potential of technology for the construction of learning, technology integration will only be achieved to the extent educators can link the tool in a natural and logical manner to the normal flow of the school curriculum, a state of affairs that has yet to be fully achieved in educational institutions (Cuban 2001; Mills & Tincher 2003).

One of the reasons for this situation is rooted in the initial training of teachers where the use of technology tends to be a mere adjunct to the syllabus for activities such as information searches. Used in this manner, technology will not be integrated pedagogically and will therefore not serve as a source of experiences that can be articulated with the teachers' professional activities (Russell *et al.* 2003; Lim 2007).

These findings have not been fully taken into account by the institutions responsible for teacher training

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(Levin & Wadmany 2008). Even though in-service teacher training initiatives explicitly recognize that the purpose behind technology integration is the improvement of teaching and learning rather than technology for its own sake, one commonly observes training processes that emphasize the instrumental or technological aspects, ignoring the fact that the mere acquisition of equipment and building of computer networks is not in itself sufficient to solve educational problems affecting the classroom (Earle 2002; Ertmer *et al.* 2003).

Because of the way these processes are structured in their application, they fail to become spaces for professional development and thus do not generate a model and/or proposition with the necessary supports to fully face the actual demands of training. Many educators who have been involved in training processes for technology integration feel that they have not obtained the necessary competencies to carry out the task and require a more thorough preparation that would equip them to deliver a higher quality professional performance (ChanLin *et al.* 2006).

As a result, teacher training scenarios in this area are weak and do not target the development of a critical and purposeful analysis of the possible relationships between technology and school (Smith & Robinson 2003).

The foregoing considerations suggest that teacher training must be at the heart of any attempt to formally incorporate technological tools into classroom activity. This training should be the basis for serious reflection that will promote the transformation of teaching practices and make a significant contribution to the adoption of technologies by teachers.

From these premises it has been argued that technology integration includes putting educational theory into practice and applying investigative findings that will empower teaching and learning. In other words, technology integration implies the application of professional competencies that encourage the efficient and effective use of pedagogical knowledge as the foundation for the enrichment of teaching (Okojie *et al.* 2006).

A central requirement for teacher training processes is to turn out skilled educators who can perform their labors in dynamic and heterogeneous situations and have the necessary competencies for integrating their knowledges in support of decisions related to the challenges of their professional activity.

It is in this context that the concept of professional competencies arises. It can be defined as the set of learnings that an individual develops from a formative programme; it includes knowledge (conceptual knowledges), skills (procedural knowledges) and attitudes (attitudinal and/or value-based knowledges) associated with this implementation. The learning results should orient the construction of the curriculum and allow formularizing concrete evaluative indicators (González & Wagenaar 2003).

With this definition in mind, the present study was undertaken in an attempt to establish the specific competencies associated with in-service teacher training processes aimed at strengthening technology integration in the classroom. We opted to carry out a bibliographic search in which a range of works reflecting realities taken from different contexts are analysed.

By systematizing the information compiled, a series of concrete knowledges (by which is meant conceptual knowledge, abilities or attitudes) were identified that the authors of the works surveyed have associated with technology integration. On the basis of these knowledges, six domains of action were defined representing the areas that should be targeted in technology integration training processes. Once the list of domains and knowledges was completed, we structured a series of proposed concrete professional competency sets that integrate in a logical and well-articulated manner those competencies which any teacher trained to integrate technology into the classroom should develop.

The purpose of this article is to determine the domains and teaching competencies that, according to the literature surveyed, are needed to support the in-service teacher training processes for technology integration. Section II provides a description of the methodology followed; Section III introduces and defines the domains encountered in the bibliographic search; Section IV structures the domains, specific knowledges and teaching competencies generated by this research; Section V contains a discussion of our proposal; and finally, Section VI presents the conclusions of our work.

Methodology

Our methodology involved the examination of a diverse range of publications from which the relevant information was gathered and then analysed. We worked

primarily with two databases, Academic Search Premier and Google Scholar.

To arrive at a selection of texts from each database that would constitute the definitive sample, six search criteria were used as detailed in Table 1. These criteria were based on the structural characteristics of the publications (text keywords, date of publication, peer-review status, completeness of text, subject area and title keywords) and their central topics (specific research subareas and foci of analysis).

Because the two databases do not have the same internal configuration, the two sets of six search criteria were not identical. The idea was to be as consistent as possible, however. For example, Academic Search Premier has a filter that allows texts to be selected according to a publication's specific subject classification – in our case, education – before beginning the actual search. This option does not exist in Google Scholar, forcing the user to choose a subject area filter. Searches in the latter database were focussed on the computer science and humanities areas.

The resulting definitive selection of texts consisted of 31 documents, of which 26 were empirical studies and 5 provided theoretical reference frameworks. This sample embraced an interesting variety of theoretical approaches, including publications from the United States, Denmark, Greece, Taiwan, United Arab Emirates, Chile, Canada, Israel, Sweden, Singapore, Turkey and Jordan. Thus, although country of publication was not a pre-established criterion, the final sample did reflect findings drawn from a range of research contexts.

The methodological procedure consisted in analysing each document's content in terms of its categories and its emerging status. The latter aspect meant that there were no predefined categories at the start of the analysis. Thus, for each article the units of meaning generated were classified into dimensions (categories) (Pasquale & Meunier 2003), all of which were built from the explicit contents of the texts in the publications analysed rather than previously existing theory (Bolívar 2002).

The quantity of documents used in generating each domain depended directly on the findings generated. Even with domains for which multiple publications were found, we chose to apply the criterion of theoretical content saturation. Under this technique the researcher collects, codes and analyses the information appearing explicitly in the text until no more data are found that broaden the properties of the category studied (Tarrés 2001; Flick 2006).

The first step in the actual process of analysis consisted in examining the chosen texts author by author, extracting the specific knowledges associated with teacher training processes in technology integration. These specific knowledges found in the documents operate methodologically as units of analysis and are given in the tables as close to the original wording as possible, that is, with the minimum necessary changes to preserve the original meaning in isolation from the source article. The analysis units were rigorously coded following the procedure explained in what follows.

This process was generated independently by each of the two authors so that their respective codings could be compared at the end of the process. At that moment each analysis unit was discussed, and only once a consensus was reached would the unit be definitively included in the appropriate matrix. In the first stage of the discussions the percentage of agreement was above 60%, but as just implied, agreement on the final version of the matrices was total.

Once the complete set of specific knowledges, which evidenced a heterogeneous character (conceptual, procedural and/or attitudinal), was established, we then proceeded to classify them based on their epistemological nature. The central criterion for this categorization was thus the area of professional educational knowledge they pointed to. On this principle of classification, six different training domains were identified. General definitions were then drafted on the basis of general conceptualizations generated from the analysed documents themselves.

In similar fashion to the classification of the specific knowledges cited in each text, the categorization of the specific knowledges by training domain was based on the analytic context of each author's concrete proposal. The original orientation of the proposals was therefore fundamental to the categorization adopted here.

The second step in our method was to construct teaching competencies from the various knowledges associated with the domains, keeping in mind their conceptual limits and the theoretical borders separating them. Within each domain the knowledges were arranged according as they were conceptual, procedural or attitudinal, and were articulated in terms of proposed competencies that emphasize this tridimensional nature of professional knowledges. In this sense the knowl-

Table 1. Summary data of texts analysed (databases, criteria and number of texts).

Database: Academic Search Premier (education)											
First phase: publication characteristics								Second phase: publication topics			
Filter 1: text keywords	Subtotal	Filter 2: date	Subtotal	Filter 3: peer-review status	Subtotal	Filter 4: completeness of text	Subtotal	Filter 5: specific research subarea	Subtotal	Filter 6: foci of analysis	Total
Technology integration classroom	442	2000–2008	346	Peer-reviewed	247	Full text	148	Teaching	34	ICT-related capabilities or competencies	17
Continuing teacher training	1190	2000–2008	981	Peer-reviewed	694	Full text	454	Technology	41	ICT-related capabilities or competencies	1
Number of analysed texts from Academic Search Premier (subtotal)											18
Database: Google Scholar											
First phase: publication characteristics								SECOND PHASE: Publication topics			
Filter 1: text keywords	Subtotal	Filter 2: subject areas	Subtotal	Filter 3: date	Subtotal	Filter 4: title keywords	Subtotal	Filter 5: specific research subarea	Subtotal	Filter 6: foci of analysis	Total
Technology integration classroom	128 000	– Computer science – Humanities	26 700	2003–2008	20 700	– Technology – Integration – Classroom	93	Teaching	12	ICT-related capabilities or competencies	7
Continuing teacher training	274 000	– Computer science – Humanities	21 600	2003–2008	19 500	– Training – Teacher	1160	Technology	38	ICT-related capabilities or competencies	6
Number of analysed texts from Google Scholar (subtotal)											13
Number of analysed texts from both databases (total)											31

ICT, information and communication technology.

edges in each domain were integrated logically, generating the competencies that should be strengthened through teacher training processes.

The coding incorporates two types of information: the nature of the knowledge developed and the competency this knowledge is linked to. The possible classifications for the first type are C (conceptual), P (procedural) and A (attitudinal). The two numbers following these letters refer to the knowledge's corresponding dimension and generic competency.

As an example, the coding for the 'planning the use of technology' knowledge is P-2.3. This indicates that the text refers to a procedural (P) type of knowledge in the pedagogical/curricular domain (2) linked directly to the third competency in the table (systematic planning of the technology's application so that it is logically integrated into classroom activity).

The competencies articulated in each domain were ordered hierarchically by degree of complexity from low to high so that, in general terms, each of them is a condition for exercising the next one. This sequencing was only applied within the individual domains, as our analysis did not extend to the determination of dependencies that might exist between competencies of different domains.

This hierarchical ordering was also coded, using two numbers. The first number indicates the competency's domain and the second indicates its position within the established sequence. For example, the generic competency 'mobilizing technical abilities for solving problems in instructional contexts' is coded 1.3, meaning that it is in the instrumental/technological domain (1) and is the third competency in the list (3).

Finally, our proposed competencies were validated by two experts in technology integration who offered concrete suggestions regarding the competencies' configurations and definitions.

Domains associated with teacher training in technology integration

The evidence suggests that technology integration is a complex category configured by multiple factors. Its nature is such that we must treat it as a generic dimension related to a diversity of variables that condition and determine its implementation (Russell *et al.* 2003; Meyers & Desiderio 2007).

In the light of the foregoing we recognized six domains that should be covered by teaching training processes aimed at strengthening technology integration in the classroom. These domains are denoted as follows: instrumental/technological, pedagogical/curricular, didactic/methodological, evaluative/investigative, communicational/relational and personal/attitudinal.

The first of the six dimensions is an *instrumental* domain that encompasses the training teachers need to develop technology-handling abilities, that is, the correct use both of hardware and specific software in an instructional context.

This training is felt by researchers such as Markauskaite (2007) to be of such importance as to form the very basis for the work to be done, stating explicitly that as educators improve their technical capabilities they also develop greater confidence in the processes required for technology integration.

In the same vein, and following the contributions of Albion (2003) on teacher training, as subjects successfully appropriate the use of technical equipment, their level of comfort with its use increases, and so, therefore, does the possibility of achieving and consolidating an integration project.

These findings would appear to confirm that if educators do not have sufficient abilities for handling a computer, it is unlikely they will be able incorporate technology into their classroom teaching, much less guarantee the pedagogical success of its implementation (Demetriadis *et al.* 2002).

The teacher's ability to handle technology is not, by itself, enough to bring about an educational change, however. The key to integration lies not so much in more equipment and greater ability to use it as in the competencies needed to conduct a systematic and well-targeted effort to promote the educational/training aspects of the equipment's incorporation (Ertmer 2005; Jung 2005).

An aspect on which we found considerable convergence in the literature analysed was the need to include *curricular* variables into the teacher training process. These variables are understood as the teacher's ability to logically articulate implementation of a technology with their institution's existing educational proposition (Cabero 2004; Fox & Henri 2005).

Cox *et al.* (2004) state that unless teachers develop the requisite pedagogical competencies, it will not be

possible to implement technology projects that bring innovate scenarios to the schools, nor will it be feasible to configure actions that drive educational change.

In this same perspective, others assert that a constituent factor in actions for integrating technology is a clear understanding on the part of teachers of the pedagogical principles that sustain these actions and orient them towards the optimization of teaching and learning (Okojie *et al.* 2006; Hew & Brush 2007).

Although there are certain basic technical requirements that teachers must meet, the technology proposition will not be integrated until the use of the technology has been planned and incorporated into a broader training proposition that succeeds in establishing a close connection between technology and the curriculum (Zhao *et al.* 2002).

Another element that research has indicated as a constituent part of a teacher training proposition has to do with *methodological* factors. These refer to the development of didactic knowledges that bolster the inclusion of technology in the educational activities implemented in the classroom.

In this sense, Li (2005) posits that any action seeking to undertake a process of technological infusion must provide the tools that enable teachers to generate learning environments connected with real, concrete experiences. The idea is to drive a broader variety of alternatives for implementing classroom learning scenarios in a relevant and motivating manner.

Within this context, the proposal consists in giving meaning and purpose to the teaching practices generated around technology implementation, applying theoretical contributions and research findings to the promotion of teaching and learning (Okojie *et al.* 2006).

Some researchers posit the existence of an *evaluative* domain that must also be incorporated into teacher training. This dimension centres on generating feedback to both the student learning processes and the general functioning of the technology implementation. In either case the evidence should be used for timely and efficient decision-making.

As regards performance analysis, Mills and Tincher (2003) note that evaluative research is a central orientation of the support provided to students in that it enables the carrying out of explanatory studies, the identification of problems and the building of possible solutions.

As for the valuation of a technology integration project, a rigorous evaluative plan will generate information necessary to improve the application of a specific technology.

From this perspective, the evaluative/investigative domain attempts to estimate the extent to which teacher training is achieving the goals initially set for it, providing evidence for adopting the corresponding solutions when they are needed.

Some studies have introduced the *relational* sphere as an essential element to be incorporated into training actions. The basis for this position is that the educational interaction of the actors (whether between teacher and student or among students) takes on a different configuration when it occurs in a technology environment.

In this context the technology can be used for collaborative work (Mills & Tincher 2003), but this would require concrete abilities in order to achieve successful negotiation and consensus processes. This aspect is of crucial importance if we focus on the mediational process conducted by the classroom teacher, whose communication competencies are what ensure that interaction and effective accompaniment of the students take place.

According to Tweddell (2007), insufficient communication results in a lower quality constructed learning environment given that it limits the effectiveness of interaction. As the author points out, obstacles posed by technology are easier to overcome than communicational ones, and it is therefore these latter that require a deeper transformation in the beliefs of the teachers themselves.

Finally, some authors have pointed to the need for incorporating a *personal* element in the adoption of technology innovations in the classroom. Their point that the attitudinal factor is what ultimately makes the difference in the quality of an implementation given that the way a technology design is interpreted and put into practice depends on the subjectivity of the teacher handling the process.

A range of studies have found that the personal dimension influences the representations of the teachers, which in turn impact on concrete pedagogical practices. Thus, for example, the teacher's self-perception generates ways of seeing, understanding and projecting the inclusion of technology in the classroom, and therefore conditions the ways of operating with it (Li 2007; Markauskaite 2007).

Some of the personal elements that influence the incorporation of technology in the classroom are the teachers' beliefs, emotions, experiences and expectations. These elements must be formally taken into account in teacher training (Wood *et al.* 2005; ChanLin *et al.* 2006).

In this framework, a training approach that aims at reinterpreting the teaching and learning process is an essential condition for such training (ChanLin 2007).

Domains, knowledges and teaching competencies for technology integration

In this section, the information compiled is organized by training domain. To better visualize our analysis, each of the six domains is displayed in a matrix containing three columns.

The first column presents the references for the texts analysed. The second column details the specific knowledges associated with each text on which the conceptualization of the corresponding domain was founded. The various knowledges are expressed as they appear in the texts and are presented in the matrices in the same order.

As noted earlier, each knowledge is followed by a code made up of a letter and a number. The letter indicates the type of knowledge, with C standing for conceptual, P for procedural and A for attitudinal. The number refers to the particular competency the knowledge in question is related to.

A conceptual knowledge is based primarily on theoretical information. A procedural knowledge, on the other hand, focuses on actions involving application and/or cognitive construction, understood as a mental elaboration by the subject. And an attitudinal knowledge is one that refers to a personal position adopted in relation to various knowledge objects.

Determining exactly how these knowledges were incorporated in the original document by the respective research team was a complex process, but the overall context in which they occurred in the text provided important clues for the task of classifying them.

The numbering of the knowledges by their corresponding competencies was adopted simply to ensure a clearer exposition of the logic of our analysis and the configuration of the proposed competencies.

Instrumental/technological domain

Of the various documents analysed, eight are knowledges relating to teacher training in the instrumental/technological domain. A total of 19 such knowledges were identified, of which 1 was conceptual, 15 were procedural and just 3 were attitudinal.

It is clear from the nature of these knowledges that they focus on actions constituting a instrumental domain aimed at applying the technology tool for the direct benefit of the class.

As is apparent in the matrix, the linkages between the knowledges and the corresponding competencies are distributed among the latter fairly homogeneously; there is, however, a greater concentration of abilities related to the management of information used in the instructional process.

Also noticeable is the relative lack of attitudinal knowledges. The few that are found state the need for teachers to appropriate the corresponding technology application.

The teaching competencies generated by our analysis encompass a broad spectrum that ranges from the mastery of technology resources to the application of technical abilities for problem-solving.

It should be noted that although the various knowledges are presented here in a technology context, their configuration is articulated within a teaching environment. The logic behind this articulation is therefore the effective implementation of teaching and learning processes (Table 2).

Pedagogical/curricular domain

Eleven specified knowledges recognizable as relating to teacher training for technology integration within the pedagogical/curricular domain were found in the analysed documents. A total of 27 such knowledges were identified, of which 12 were conceptual, 13 were procedural and just 2 were attitudinal.

Particularly important is the number of conceptual knowledges in this domain. These relate mainly to the understanding of pedagogical theories that should orient professional teaching activity.

Also evident is the small number of attitudinal knowledges. These focus on the empowerment teachers must develop around the pedagogical use of technology tools in the classroom.

Table 2. Instrumental/technological domain: knowledges and competencies.

I Instrumental/technological domain		
Author	Knowledges specified in text	Proposed competencies
Markauskaite (2007).	Developing competencies in using ICTs. **P-1.1** Using ICTs as a mental tool. **P-1.3** Developing technical and cognitive capabilities. **P-1.3** Articulating technical and cognitive capabilities (problem-solving and information processing). **P-1.3** Analysing and producing information with ICTs. **P-1.2** Finding, managing and integrating information. **P-1.2** Evaluating information based on ICTs. **P-1.2**	1.1 Mastery of a variety of technology resources associated with the instructional process. 1.2 Managing information relevant to, and important for, the instructional process based on work with technology sources. 1.3 Mobilizing technical abilities for solving problems in instructional contexts.
Zhao *et al.* (2002).	Knowledge of the use of the technology. **C-1.1**	
Bauer (2005).	Using computers effectively in the classroom. **P-1.1**	
Li (2005).	Empowerment in the use of the technology. **A-1.1**	
Lawless and Pellegrino (2007).	Using technology resources in daily routines (computers, specialized software, systems and other infrastructure). **P-1.1**	
Albion (2003).	Development of abilities for using ICTs. **P-1.1** Being comfortable and familiar with the software. **A-1.1** Appropriation of the use of the computer. **A-1.1**	
Mills and Tincher (2003).	Operating common (basic) technology. **P-1.1** Using ICTs for productivity and managing information. **P-1.2** Applying the technology to solve problems. **P-1.3** Applying problem-solving strategies in class (related to ICTs). **P-1.3** Using the technology to identify, evaluate and collect information from a variety of sources. **P-1.2** Evaluate the validity of generated information using the technology. **P-1.2**	
Okojie *et al.* (2006).	Identifying sources for additional instructional materials using the technology. **P-1.2**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

A detailed analysis of these knowledges and their links with the stated competencies identified that the knowledges relate primarily to the first two competencies, namely, pedagogical decision-making and the integration of a technology's application into the preexisting curriculum proposition.

Nevertheless, even though the knowledges relating to the third and fourth competencies are relatively few, there are a variety of associated foci of professional action ranging from decision-making to the creation of pedagogical propositions that effectively promote construction of knowledge by students (Table 3).

Didactic/methodological domain

Eighteen integrated specific knowledges associated with teacher training were found in the documents. A total of 37 such knowledges were identified, of which 1 was conceptual, 36 were procedural and none was attitudinal.

Analysis of these knowledges shows that their focus is the development of abilities needed for putting concrete didactic methods into practice within the framework of a technology project.

It is interesting to note that even though this domain includes more knowledges than any other, and is the area most often referred to in the specialized literature, no specific attitude was mentioned as favouring technology integration.

A careful review of the relationships between the knowledges and the various proposed competencies demonstrates that the one most emphasized relates to the design of technology applications within the teaching process. This is totally consistent with the analysis in the immediately preceding paragraphs.

Table 3. Pedagogical/curricular domain: knowledges and competencies.

	II Pedagogical/curricular domain	
Author	Knowledges specified in text	Proposed competencies
Markauskaite (2007).	Mastering a range of educational paradigms with which to use ICTs. **C-2.1** Mastering a range of evaluative paradigms for using ICTs. **C-2.1** Understanding the policy dimension of ICTs for teaching and learning. **C-2.1**	2.1 Making pedagogical and curricular decisions that take into account the teaching purpose of the technology's use within diverse educational paradigms. 2.2 Integrating the technology's application with development of a given pedagogical and curricular proposition. 2.3 Systematic planning of the technology's application so that it is logically integrated into classroom activity. 2.4 Implementing processes for applying the technology that promote construction of knowledge by students.
Zhao *et al.* (2002).	Planning the use of technology. **P-2.3** Connecting technology with a pedagogical and curricular proposition. **P-2.2** Integrating technology with teaching. **P-2.2** Determining the support provided by the technology to the accomplishment of curricular goals. **P-2.2**	
Rehbein *et al.* (2003)	Understanding the potential and limitations of computers. **C-2.1**	
Okojie *et al.* (2006).	Understanding pedagogical principles that orient the classroom use of the technology. **C-2.1** Relating the technology to pedagogical concepts. **C-2.1** Connecting the technology with objectives, instruction methods, and styles and rates of learning. **C-2.2–2.3** Reflecting upon the use of the technology and reducing the tendency to introduce it mechanically. **A-2.1–2.4** Taking into account learning principles and the orientation of the teaching methodology. **C-2.1–2.2** Recognizing the existing relationship between the technology, education and pedagogical decision-making. **C-2.1** Identifying learning objectives in technology-based instruction. **P-2.3** Recognizing the technology as a tool that can be used pedagogically. **C-2.1** Adapting the technology to learning activities. **P-2.2** Selecting a technology that is appropriate to the instruction plan. **P-2.2** Selecting and/or adapting the technology to objectives based on students' needs. **P-2.2** Choosing methods that are relevant to objectives, the selected methodology, and the styles, modes and rates of learning. **P-2.2**	
Popejoy (2003).	Using technology in context, matching hardware and software combinations to the needs and abilities of learners and the instructional objectives. **C-2.2–2.3**	
Levin and Wadmany (2008).	Integrating the technology into a pedagogical proposition. P-2.2	
Zhao and Bryant (2006).	Integrating technology into the curriculum. **P-2.2**	
Steketee (2005).	Integrating ICT, not as an 'add on' but as an integral tool that is accessed by teachers and students across a wide range of curricula. **P-2.2**	
ChanLin (2005).	Achieving curricular objectives. P-2.2 Curricular objectives should be achieved. **P-2.2**	
Li (2005).	Rethinking the assumptions of the pedagogical proposition. **C-2.1–2.2** Rethinking contents and objects and their relationships with the technology. **C-2.2–2.3** Review the reasons for integrating the technology into specific subject area activities. **P-2.1–2.2** Adopting pedagogical approaches in the most appropriate manner. **P-2.3–2.4** Empowerment regarding the purpose of the technology. **A-2.1** Broadening perspectives on technology integration. **C-2.4**	
Mills and Tincher (2003).	Applying the technology through the curriculum. **P-2.2**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

Even so, the array of competencies is quite broad, ranging from instructional design to the generation of environments that promote learning (Table 4).

Evaluative/investigative domain

Five specifying concrete knowledges associated with teacher training in this domain were chosen from the documents. A total of 20 such knowledges were identified, of which none were conceptual, 16 were procedural and 4 were attitudinal.

The nature of the knowledges suggests that this domain emphasizes the strengthening of the abilities for practical application of the technology in the classroom.

Although attitudinal knowledges in this domain are few, their inclusion is relatively significant given that they are centred on teachers' self-critical pedagogical practices.

The distribution of the links between the knowledges and the various proposed competencies as shown in the matrix clearly indicates that the emphasis is on the second competency, which relates to the impact of feedback to student learning through technology tools.

The competencies are structured around three different areas of focus. The first refers to the evaluation of student learning, the second to the valuation of the technology project itself, and the third to the self-evaluation by the teacher of his or her own teaching practices within the technology integration framework (Table 5).

Communicational/relational domain

Ten specified concrete knowledges associated with teacher training in this domain were found in the documents. A total of nine such knowledges were identified, of which two were conceptual, two were procedural and five were attitudinal.

The majority of the nine knowledges are attitudinal in nature and are basically related to the generation of interpersonal capabilities for creating collaborative networks with other actors, whether students, parents/guardians or professors.

The competency that concentrates the greatest number of knowledges is the second one, which focuses on the use of technology for the purpose of improving communicational and collaborative channels with all members of the education community.

All of the competencies are oriented towards educational interaction, but revolve around the configuration of relevant social scenarios that strengthen the teaching and learning processes (Table 6).

Personal/attitudinal domain

Seventeen specified concrete knowledges associated with teacher training in this domain were found in the documents. A total of 15 such knowledges were identified, all of which were attitudinal.

This domain is the only one whose knowledges are all attitudinal; those of a conceptual or procedural nature are thus excluded.

The linkages between the knowledges and the various proposed competencies as shown in the matrix demonstrate that most of the knowledges are concentrated on the first competency, which relates to the reinforcement of positive attitudes toward technology integration in the classroom.

Due to the nature of this domain, all of its knowledges and competencies focus on developing a subjective willingness to change that opens the way to the transformation of teaching.

The competencies are not confined to this goal, however, for they also embrace such notions as the improvement of self-perception and greater professional flexibility in the application of technology projects (Table 7).

The relationship between the various training domains and their corresponding generic competencies is summarized in Table 8.

Discussion

Our analysis established a number of domains that configure in-service teacher training processes in the area of technology integration. The domains include technological, curricular, methodological, evaluative, communicational and personal elements.

The presence of these different domains in the research articles studied was found to be quite heterogeneous. Whereas some were strongly emphasized, such as the didactic/methodological domain, which also contains a large number of knowledges, others, such as the communicational/relational domain, were identified by fewer writers and specified few knowledges.

Table 4. Didactic/methodological domain: knowledges and competencies.

III Didactic/methodological domain		
Author	Knowledges specified in text	Proposed competencies
Li (2005).	Reviewing how to integrate the technology into specific subject area activities. **C-3.1** Projecting real applications of the technology. **P-3.1** Designing and developing experiences with technology support. **P-3.1–3.2–3.3**	3.1 Designing concrete technology applications in the classroom within the instructional process. 3.2 Strengthening the classroom teaching proposition through the implementation of technology tools. 3.3 Promoting student learning through the application of technology tools in the classroom. 3.4 Creating complementary methodological resources based on work with technology sources. 3.5 Generating a motivating and collaborative learning environment through technology integration in the classroom.
Okojie *et al.* (2006).	Applying theory and research findings to the promotion of teaching and learning. **P-3.2–3.3** Designing the use of the technology in an instructional context. **P-3.1** Planning instruction using the technology. **P-3.1** Using existing tools, equipment and materials to promote learning. **P-3.3** Designing a dynamic instruction using the technology. **P-3.2** Imparting instruction using the technology as part of the educational process. **P-3.2** Developing technology-enriched materials. **P-3.4** Using the Internet and multimedia networks to prepare supplementary learning materials. **P-3.4** Increasing instructional resources with the support of the knowledge and abilities acquired. **P-3.4** Providing a motivating and interactive learning environment that encourages recourse to the technology for discovering knowledge on one's own. **P-3.5**	
Al-Mujaini (2006).	Integrating computer technology into lesson plans. **P-3.2** Implementing computer technology in classrooms. **P-3.2**	
ChanLin (2005).	Using technology to provide a pedagogical tool for creating experiences for learning. **P-3.3** Developing an appropriate practice in the planning and use of various technology tools. **P-3.1–3.2**	
Lim (2007).	Integrating ICT as an integral or mediated tool for carrying out specific teaching or learning activities to meet certain instructional objectives. **P-3.3**	
Markauskaite (2007).	Using ICTs as a teaching tool. **P-3.2** Producing ICT information/materials. **P-3.4** Analysing student needs that require support from ICTs. **P-3.2** Planning ICT use in classes. **P-3.1** Configuring ICTs for learning activities. **P-3.2** Creating ICT-enriched classes. **P-3.2–3.4**	
ChanLin *et al.* (2006).	Integrating new strategies with existing strategies. **P-3.1**	
Jung (2005).	Generating ICT-based learning environments. **P-3.5**	
Zhao *et al.* (2002).	Determining the support provided by the technology to the teaching process. **P-3.1–3.2** Taking into account the conditions of use of the technology. **P-3.1** Generate appropriate technology environments. **P-3.5** Taking into account the real limits existing in the classroom for such applications. **P-3.1** Evaluating the technology's strengths and weaknesses. **P-3.1**	
ChanLin (2007).	Using technology to enhance instruction. **P-3.2** Using technology to create rich environments that help each individual student develop a deep understanding and critical thinking skills. **P-3.3**	
Ertmer (2005).	Relating the technology required for the immediate demands of a given context to their satisfaction. **P-3.1**	
Hughes and Ooms (2004).	Using technology to support student learning. **P-3.3**	
Levin and Wadmany (2008).	Selecting the technology that will be used in the class. **P-3.1**	
Hew and Brush (2007).	Using computing devices for instruction. **P-3.2**	
Oncu *et al.* (2008).	Deciding which technology will be used in the class (establishing criteria and conditions for the task). **P-3.1**	
Mills and Tincher (2003).	Recreating and reorganizing learning environments. **P-3.5** Modeling the use of the technology in the classroom. **P-3.1** Applying the technology to facilitate collaboration and cooperation among students. **P-3.3–3.5** Conduct learning activities using the technology. **P-3.2–3.3** Selecting technology resources for use in class. **P-3.1** Using the technology to impart instruction. **P-3.2** Integrating learning experiences based on the technology into the instruction imparted. **P-3.2–3.3** Using the technology to facilitate individual and cooperative learning experiences. **P-3.3–3.5** Using the technology to create learning environments. **P-3.5**	
Orhun (2003).	Changing the roles of teachers from transmitters of knowledge to facilitators and managers of learning. **P-3.3**	
Demetriadis *et al.* (2002).	Adapting the use of ICTs based on investigative evidence. **P-3.1**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

Table 5. Evaluative/investigative domain: knowledges and competencies.

IV Evaluative/investigative domain		
Author	Knowledges specified in text	Proposed competencies
Mills and Tincher (2003).	Guiding students using multiple evaluation methods. **P-4.1** Using the technology to maintain and analyse student performance. **P-4.2**	4.1 Implementing evaluation alternatives that are logically integrated with both the instruction plan and the technology implementation.
Markauskaite (2007).	Evaluating the technology alternatives for use in the classroom. **P-4.2** Developing self-evaluative processes. **A-4.4** Developing metacognitive processes. **A-4.4** Evaluating alternatives for ICT use. **P-4.2** Critically evaluating one's own practices. **A-4.4**	4.2 Systematically monitoring and providing feedback to student learning using evaluation strategies based on the use of technology tools.
Okojie *et al.* (2006).	Evaluating learning strategies. **P-4.3** Designing evaluative follow-up processes using the technology. **P-4.2** Choosing technologies to evaluate learning needs. **P-4.1–4.2** Using technology to evaluate instruction. **P-4.2** Using relevant technology for follow-up of learning activities. **P-4.2** Evaluating pertinence of the technology to instruction plan. **P-4.3** Evaluating pertinence of the technology to learning products. **P-4.3** Evaluating whether chosen technology is adequate for lesson objectives, instruction methods, evaluation, feedback and learning process follow-up. **P-4.3** Selecting evaluative techniques pertinent to objectives, instruction methods and technologies used. **P-4.1** Selecting appropriate follow-up materials pertinent to instruction objectives and technologies. **P-4.1**	4.3 Evaluating the relevance and effectiveness of the implemented technology application, making timely decisions for improving the instruction process developed. 4.4 Implementing self-evaluation processes reflecting one's own beliefs and pedagogical practices regarding technology integration in the classroom.
Levin and Wadmany (2008).	Continuous questioning of one's own decisions and instructional practices. **A-4.4**	
Li (2005).	Ability to reflect and evaluate. **P-4.4** Monitoring and providing feedback to student learning. **P-4.2**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

This variation provides clues to the logic that guides teacher training in technology integration, for which efforts have been oriented principally toward the methodological implementation of technology while tending to neglect the social and interactive aspects of in-service teacher training.

On the basis of the information generated, we believe that further progress is required in the search for a structure within which these various domains can be articulated. This would involve determining such aspects as the order in which to sequence them, the relative amounts of training time spent on each domain, and what type of relations to establish between them. The work presented here posits a sequential dependency between competencies belonging to a single domain, but does not probe into how a given competency relates to those in other domains. This articulation is central to the configuration of an operational logic for action on training.

In our view, then, there is a need to build training models that reinforce teaching competencies which support the incorporation of technology in institutional

Table 6. Communicational/relational domain: knowledges and competencies.

V Communicational/relational domain		
Author	Knowledges specified in text	Proposed competencies
Mills and Tincher (2003).	Using the technology to communicate and collaborate with students, peers, parents/guardians and the community. **A-5.2**	5.1 Generating appropriate social environments in the classroom that promote positive disposition towards the application of the technology.
Zhao *et al.* (2002).	Generating interactions with others (e.g. the technology coordinator). **A-5.2**	5.2 Using technology to communicate information and collaborate both with students and the rest of the education community.
	Knowledge of the social and organizational aspects of the school. **C-5.2**	
	Generating appropriate social environments. **A-5.1**	
Sternberg *et al.* (2007).	Generating discussions between teachers and colleagues, consultants and professors (e.g. workshops and professional learning communities) **A-5.2**	5.3 Putting into practice interpersonal competencies consistent with the implemented technology.
Reneland and Ahlbäck (2007).	Establishing group culture and a common ground (exchange of experiences). **A-5.2**	
ChanLin (2005).	Using technology to work with the community (school principle or supervisor, teachers' colleagues, students and students' parents). **A-5.2**	
Okojie *et al.* (2006).	Developing motivational strategies for the students. **P-5.1**	
Rehbein *et al.* (2003)	Using electronic communication strategies. **P-5.1**	
Jung (2005).	Using technology to communicate with a larger international teaching community. **P-5.2**	
Lawless and Pellegrino (2007).	Using technology-based practices in daily routines (collaborative work and communication). **P-5.2**	
Markauskaite (2007).	Understanding the social aspects of the use of ICTs in education. **C-5.1**	
	Communicating information to others. **P-5.2**	
	Developing communicational and interpersonal capabilities. **A-5.3**	
	Collaborating on consensus solutions. **A-5.2**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

training processes, employing it as an integral tool with various uses and an inherent potential for promoting teaching and learning in diverse educational situations.

This work is therefore a useful framework that acts as an aide-memoire for teacher trainers engaged in designing and implementing in-service education courses. Within this framework it is possible to generate teacher training profiles that orientate the training work to be done. These profiles could be configured as targets so that the training received by the teachers could be evaluated with greater precision.

But such a model would also have to concern itself with the training starting point, that is, the theoretical and empirical bases from which a given process should begin. Indeed, an ongoing focus of discussion is the extent to which an in-service training process should address the professional deficiencies generated since the initial pre-service training.

In any event we should recall, in line with Lawless and Pellegrino (2007), that technology integration implies the incorporation of technology resources and technology-based practices into the daily management of schools, thereby promoting the qualitative improvement of the educational goals. Any improvements in training actions carried out at schools should be articulated with this objective in mind.

Table 7. Personal/attitudinal domain: knowledges and competencies.

VI Personal/attitudinal domain		
Author	Knowledges specified in text	Proposed competencies
Markauskaite (2007).	Developing confidence in ICTs as technologies. **A-6.1** Developing confidence in ICTs as a tool for promoting the quality of teaching and learning. **A-6.1** Developing self-efficacy beliefs. **A-6.2**	6.1 Developing an open and positive attitude towards technology integration, visualizing its possible contribution to the promotion of learning. 6.2 Strengthen an efficacy self-perception regarding technology to support the putting into practice of an appropriate teaching role for the instructional process. 6.3 Generating a flexible cognitive and emotional disposition toward changes in one's perspectives on teaching and the transformation of one's pedagogical practices.
Rehbein *et al.* (2003)	Feeling confident enough in handling the computers. **A-6.1**	
ChanLin (2005).	Interest in using computers. **A-6.1** Before teachers use technology they must be personally convinced of its benefits. **A-6.1**	
Zhao *et al.* (2002).	Good attitudes **A-6.1** Reflecting on one's owns beliefs regarding teaching and technology. **A-6.3** Approaching educational change gradually (evolution, not revolution). **A-6.3**	
Pedersen and Marek (2007).	Reflecting on teaching and technology **A-6.1**	
Li (2005).	Positive attitudes. **A-6.1**	
Zhao and Bryant (2006).	Confidence in the use of technology for instructional purposes. **A-6.1**	
Ertmer (2005).	Confidence in the use of the technology. **A-6.1**	
Steketee (2005).	Developing self-efficacy in their ICT competencies. **A-6.2**	
Okojie *et al.* (2006).	Confidence in the technology that will be used. **A-6.1**	
Wang *et al.* (2004).	Belief in one's capacity to work effectively with technology. **A-6.1**	
Oncu *et al.* (2008).	Generating positive expectations regarding technology integration in the classroom. **A-6.1** Strengthening confidence in the use of technology in the classroom. **A-6.1**	
Albion (2003).	Positive attitudes toward the use of ICTs. **A-6.1**	
Hernández-Ramos (2005).	Developing a flexible attitude to integrate technology into the classroom. **A-6.1**	
Levin and Wadmany (2006).	ICT enhances the learning process. **A-6.1** Positive beliefs on the role of technology in the classroom. **A-6.1**	
Levin and Wadmany (2008).	Generating a system of positive beliefs associated with technology. **A-6.1** Being cognitively and emotionally open to changing one's teaching practices and perspectives (novelty and uncertainty). **A-6.3**	
Demetriadis *et al.* (2002).	Considering oneself capable of integrating technology into one's instructional practice. **A-6.2**	

C, Conceptual; P, Procedural; A, Attitudinal; ICT, information and communication technology.

Conclusions

This article set out to define a set of teaching domains and competencies around which teacher training for technology integration should be organized. The systematization we have developed is a starting point for such an effort. Because the method adopted was a bibliographic search using the content saturation criterion,

Table 8. Summary of generic competencies by domain.

Generic competencies
I Instrumental/Technological Domain
1.1 Mastery of a variety of technology resources associated with the instructional process.
1.2 Managing information relevant to, and important for, the instructional process based on work with technology sources.
1.3 Mobilizing technical abilities for solving problems in instructional contexts.
II Pedagogical/Curricular Domain
2.1 Making pedagogical and curricular decisions that take into account the teaching purpose of the technology's use within diverse educational paradigms.
2.2 Integrating the technology's application with development of a given pedagogical and curricular proposition.
2.3 Systematic planning of the technology's application so that it is logically integrated into classroom activity.
2.4 Implementing processes for applying the technology that promote construction of knowledge by students.
III Didactic/Methodological Domain
3.1 Designing concrete technology applications in the classroom within the instructional process.
3.2 Strengthening the classroom teaching proposition through the implementation of technology tools.
3.3 Promoting student learning through the application of technology tools in the classroom.
3.4 Creating complementary methodological resources based on work with technology sources.
3.5 Generating a motivating and collaborative learning environment through technology integration in the classroom.
IV Evaluative/Investigative Domain
4.1 Implementing evaluation alternatives that are logically integrated with both the instruction plan and the technology implementation.
4.2 Systematically monitoring and providing feedback to student learning using evaluation strategies based on the use of technology tools.
4.3 Evaluating the relevance and effectiveness of the implemented technology application, making timely decisions for improving the instruction process developed.
4.4 Implementing self-evaluation processes reflecting one's own beliefs and pedagogical practices regarding technology integration in the classroom.
V Communicational/Relational Domain
5.1 Generating appropriate social environments in the classroom that promote positive disposition towards the application of the technology.
5.2 Using technology to communicate information and collaborate both with students and the rest of the education community.
5.3 Putting into practice interpersonal competencies consistent with the implemented technology.
VI Personal/Attitudinal Domain
6.1 Developing an open and positive attitude towards technology integration, visualizing its possible contribution to the promotion of learning.
6.2 Strengthen an efficacy self-perception regarding technology to support the putting into practice of an appropriate teaching role for the instructional process.
6.3 Generating a flexible cognitive and emotional disposition toward changes in one's perspectives on teaching and the transformation of one's pedagogical practices.

the matrices created for the purpose could be further enriched by extending the analysis to other publications in order to obtain additional ideas. This work is thus open to critical revision by others who wish to complement it with their own researches.

On the basis of our analyses, we conclude that six foundational domains of teacher training processes in technology integration can be identified: instrumental/technological, pedagogical/curricular, didactic/methodological, evaluative/investigative, communicational/relational and personal/attitudinal.

Each of these domains can be associated with a set of teaching generic competencies that operationalize the teacher training processes involved.

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