Teaching in the Knowledge Society: Between Technology and Competences

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Introduction

The Internet and all services on it have changed and are continuously changing mankind and human society, due to the effects they have on information management and communication; otherwise stated, they are influencing individuals' learning, knowledge development and, more generally, interpersonal and intra-personal relationships. The phenomenon has been widely analyzed since its origins, and many studies have confirmed that the IT/ICT provided deep changes on learning environments, either formal, non-formal or informal (Conner 1995, 2004); it is useful to recall here, that the influence of the above environments on the different stages of human development is changed too, together with the effects of digital technologies on intentional and unexpected learning.

Furthermore, the Internet has been considered responsible for the differences affecting people in their access to information and its management. More specifically, the words "digital divide", once identifying the lack of communication equipment in underdeveloped countries, are today used to describe a growing problem in the developed countries (Bindé et al. 2005; Guidolin 2005); they describe at least:

(a) The gap in the pre-existing personal differences, between people who can use technologies (i.e. those who are able in the use of IT/ICT), and those who cannot
(b) The gap in the content management between people who master it (i.e. they can use the IT/ICT to manage information, knowledge, know how etc.), and those who do not

In this context, the analysis of Bauman (2006) regarding today's society has a special relevance, together with his definition of "liquid modernity"; following Bauman's idea,

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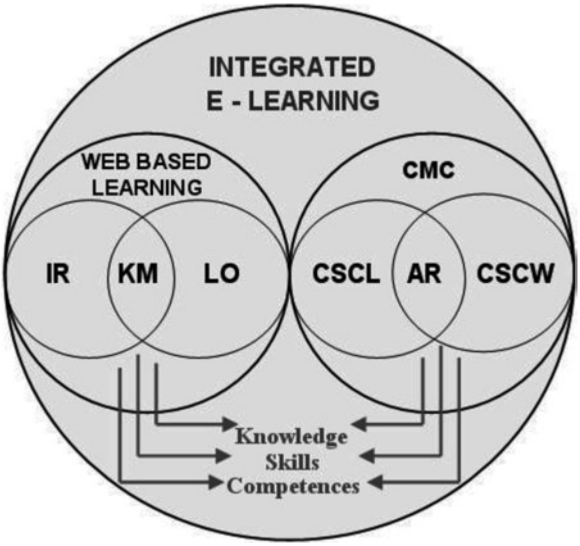

Fig. 1 Model for integrated e-learning strategies (by L. Galliani)

the destruction of the certainties in the liquid life forces the subjects to adapt to group behaviour, to avoid exclusion. It well explains the explosion of the phenomenon of social networks and the reinforcement of the definition of "digital natives" (Prensky 2001), for the young generations, against the definition of "digital immigrants", used for elder people or at least for those who were not born in the digital era.

As a result of the above issues the following questions arise:

- How many theories and models coming from educational research are used by public institutions and governments to produce real innovation or, at least, better results in everyday teaching?
- What role the school has in today's society in helping students to develop self-learning skills, meta-cognitive abilities and lifelong learning strategies?
- What role do digital technologies have in everyday teaching-learning processes for the improvement of the quality of teaching and to help students overcome their problems and difficulties?

A first answer to the above questions has been given by Galliani (2004), who proposed an integrated model for the e-learning instruments and methods to be used at school. In his model two main elements determine the development of students' knowledge, skills and competences: web-based learning (WBL) and computer-mediated communication (CMC).

Both of them have a complex structure and are based on other elements. For the features of the web, the most relevant elements to be used for students' learning are in the following: information retrieval (IR), knowledge management (KM) and the use of learning objects (LOs). The CMC, on the other hand, induces and improves social actions, like computer supported collaborative learning (CSCL), computer supported collaborative work (CSCW) and action research (AR). Figure 1 synthesizes the structure of that model, which is used here as framework for the analysis of the experience the author had with the schools taking part in an Italian project for teaching innovation (i.e. the *Innovascuola* project).

The most relevant aspects to focus on in that experience have been:

(a) The involvement of the author in the schools' projects, that is: the analysis of teachers' backgrounds, the planning of training activities, the proposal of the instruments and strategies to be adopted and the support to the creation of learning units for students
(b) The results from an investigation on digital competence assessment, which has been used to obtain suggestions and ideas on new teaching units of learning in everyday school work

Each of them will be better analyzed in the following sections.

The *InnovaScuola* Project and the Teachers Working on It

The work the author made with the teachers engaged in the *Innovascuola* project has been the result of the agreement between the Laboratory for Teaching and Learning Technologies, in the University of Cassino, and the funded schools.

The laboratory, managed by the author, had to support the schools in the choice of the instruments to be used for teaching, helped them in planning the strategies to be adopted in everyday school work and supported them in the production of learning units.

The constraints for the decisions to be adopted by the teachers were as follows:

- The introduction of new instruments and processes in the schools had to respect the commitment of the projects, which were approved by the Public Agency charged of their evaluation
- Teachers' training had to be based on the knowledge and skills that the same teachers involved in the project already had

The InnovaScuola *Project*

Since 2006, the Italian Ministry of Education has proposed the introduction of Interactive Whiteboards (IWBs) in the schools, to produce direct and effective changes in teaching-learning processes. This choice came after may be 20 years of projects for the introduction of computer science, and more generally multimedia, IT/ICT and new technologies in education (Cartelli 2002). The main differences with past experiences were as follows: (a) no computing topics (i.e. computer structure and functions, algorithm development, computer programming etc.) were now introduced in study curricula, (b) teachers were directly involved in the digital revolution, which had the students at its core attention, because they had to actively and collaboratively involve students in the construction of their knowledge and skills, and had to use the strategies of web 2.0 for hitting this target (DIT 2010).

Table 1 Basic computing knowledge and skills held by teachers

Topics and skills needed	% of positive answers
1. Basic structure and operation of a computing system (creating folders, copying files, saving information etc.)	100
2. Advanced operation on a computing system (back-up and restore of data, clearing and defragmenting the system, connecting and managing devices etc.)	9
3. Using a word processor (at home and at school)	100
4. Using a spreadsheet (at home and at school)	31
5. Using a presentation manager (at home and at school)	56
6. Browsing the web frequently	75
7. Communicating by e-mail periodically (at least once or twice a week)	53
8. Editing of images	12
9. Web editing	3

The project started in 2008, when the Ministry of Education provided the equipment and the funds to the schools winners of the national competition for the best teaching projects. Main obligations for the competitor schools were:

- To propose and carry out a biennial educational project, centred on the use of learning objects (LOs)
- To make up at least 20 LOs/year (by each school) and upload them on a national virtual space (i.e. on a platform for LOs distribution)
- To make LOs Scorm 1.2 compliant and based on Open Source software

The schools could subscribe agreements with firms, corporate, associations and universities to carry out their projects; the agreements had to guarantee the support for the choice of the equipment and the training of the teachers. At last, it has to be noted that teachers could be rewarded for the extra work they made to create LOs.

The Schools and the Teachers Involved in the Project

As soon as the competition ended, four school networks (i.e. groups of schools made of at least one public institution), three in Southern Latium and one in Molise (Central Italy regions), could start their projects in cooperation with the laboratory managed by the author.

In the first joint meeting with all stakeholders a survey was made to investigate teachers' features and basic skills, and the following data were collected:

- Thirty-six teachers (may be 10% of the whole set of teachers in the schools), were working on the school projects; they were from Primary Schools and Junior High Schools
- The answers to the questionnaire showed that almost all the teachers had the basic computing skills and knowledge, but only a little minority among them had the pre-requisites for their immediate involvement into the projects. The data from the questionnaire are synthesized in Table 1, where the percentage of positive answers to the various questions is reported

The interviews the author had with the teachers, after they answered the questionnaire, produced the following supplement of information:

- Only three teachers (9%), knew of the existence of Open Source software (e.g. the suite of office automation Open Office), and only one teacher really used it
- Those who responded positively to question eight had in mind MS Paint (included in the MS Windows operating system), which is not a proper image editor
- No teacher had former experiences with e-learning platforms
- Almost all teachers had preconceptions on the use of IWBs (Interactive White Boards); they thought they could use IWBs only to show multimedia materials to the class

As a result, teachers had to be trained on the use of most common digital instruments and on their introduction in teaching processes. On the side of the instruments the following Open Source tools complying to the requests of the project were adopted: Open Office, as the tool for office automation; Gimp and/or Paint.net, for image editing; Exe-learning, for learning objects management (it can create LOs SCORM 1.2 compliant), Moodle has been the e-learning platform suggested to teachers for online activities.

To let teachers experience the features of the e-learning platform they were allowed access to a Moodle platform, and all the materials used both in the kick-off meeting and during the different lectures have been put online and made available in that environment.

A few meetings on the description of the features of the software followed, and two lectures with the main aim of soliciting the teachers' interest on the following topics were made. First, the dependence of the creation of learning objects from the different involvement of the various actors (i.e. students and teachers) was showed; otherwise stated, different psycho-pedagogical paradigm which could inspire the use of LOs were reported, depending on the students and teachers involvement in teaching-learning work. Second, suitable topics to focus on for the planning and the development of suitable disciple and cross-discipline units of learning in the classes had to be found (all based on the creation of LOs and the use of IWBs).

The approach described above led teachers to be persuaded that:

- The equipments and the LOs could be used in different ways in the classes
- The choice of a given psycho-pedagogical approach in teaching–learning activity does not exclude other approaches (i.e. other psycho-pedagogical paradigms), also in the same activity

Before passing to the planning and creation of LOs by the teachers, the following topics were proposed for discussion:

- The results from the OECD-PISA surveys, which showed the low level of the scores obtained by Italian students to verbal-linguistic and logical-mathematical questions
- The data coming from an international competition called "Beaver", used for the assessment of students' digital competences. This last issue was the natural consequence of the discussions on the features of the net generation and the differences between digital natives and digital immigrants (Prensky 2001; Mantovani and Ferri 2008)

The last two arguments are widely analyzed in the next section and the guidelines for the development of learning objects to be created collaboratively in the classes are proposed soon after.

Students' Learning and Digital Competence Assessment

The discussions on the low level of the Italian students' performance in the OECD-PISA surveys have been very useful to introduce the more general question of students' learning difficulties.

Knowledge Construction, Meaningful Learning and Students' Problems

When looking at knowledge construction, two main positions must be considered. On one hand, individuals' learning is compared with the structure of scientific disciplines and evaluation/assessment strategies are used to express the compliance of the subject's personal knowledge with the scientific knowledge. On the other, when knowledge development is mainly analyzed from social constructivist and cultural viewpoint, the comparison with scientific knowledge is on the background, and self-consistency, activity, support and scaffolding elements are paramount. Otherwise stated, in the first case the teachers/scholars attention is centred on discipline knowledge, in the last case individual knowledge phenomena are the main object of analysis.

The above approaches have their counterpart in the definitions used to describe the problems that students meet in explaining natural phenomena, especially when there is a comparison with the right scientific explanations.

By adopting the first viewpoint, Driver and Erickson (1983) defined nomothetic – the studies which evaluate the correctness of people's ideas with respect to the scientifically accepted paradigms; on the other hand, they called ideographic – the studies on the ideas that people show when they explain phenomena with no dependence from scientific paradigms (i.e. only the internal coherence of the people's concepts and ideas is evaluated).

Together with the work of Driver and Erickson, many investigations and researches have been made all over the world in the 1970s and in the 1980s, to find instruments and strategies helping people overcome the difficulties they meet in the study of scientific disciplines and in learning new topics (i.e. recent investigations have shown that misconceptions and mental schemes do not affect only natural sciences and/or technical knowledge like IT and ICT, they are also present in history, literature and other cross-disciplinary fields).

Despite the lack of a unique approach to the solution of the students' learning problems, many situated analyses and *ad hoc* instruments and strategies (Jonassen 1994) have been proposed during last decades (i.e. those experiences were mostly based on interactive and social constructivist approaches, often based on the use of special equipments, and produced very good effects on the classes involved in the experiments). Traces of the fragmentation of the interventions can be found in the educational chapters and special interest groups of the different scientific associations (like those of mathematicians, physicians, biologists, computer scientists etc.). The most successful experience in the creation of a cross discipline, which studied people's learning, has been made by the Meaningful Learning Research Group (MLRG, http://www.mlrg.org); within it, four international conferences were organized, many hundreds of papers on the above topics were published, and Novak ideas on knowledge maps were developed and proposed to teachers (Novak and Gowin 1984).

At last, it must be noted that no final answer has been given to students' learning problems. An explanation for the above statement can be found in the result from the studies the author lead in computer science with high school students (Cartelli 2003): when preconceptions and misconceptions appear defeated, also by the use of technology and the application of constructivist strategies, they can reappear in special cases.

Digital Literacy, Digital Competence and Beaver Competition

On the basis of the issues reported above, the different meanings of digital divide proposed in the introduction assume now the features of special learning difficulties that people may have. With respect to other knowledge fields, different proposals of literacy have been recently developed, with the help of computer science and information technology, under the hypothesis that they could prevent people's difficulties.

Computing literacy, information literacy, IT/ICT literacy and media literacy are the most famous ones, and they have also been compared by Tornero (2004), who proposed the definition of digital literacy as the literacy for the knowledge society.

The most recent and comprehensive definition for this literacy is as follows: "Digital Literacy is the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyze and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action; and to reflect upon this process" (Martin 2005).

Very recently the attention of researchers and institutions has focussed on how people use digital resources and processes, more than on the things they must know and be able to do with technologies. This new approach to the analysis of the impact of new technologies on mankind led to the concept of competence, and on the active involvement of subjects in the interaction with digital equipments, without forgetting the representations of reality, the knowledge and the skills that people manifested (Le Boterf 1990).

On this side, the European Commission issued in 2005 the "Recommendation on key competences for lifelong learning" and stated the features of the digital competence, the fourth among them (Commission of the European Parliament 2005).

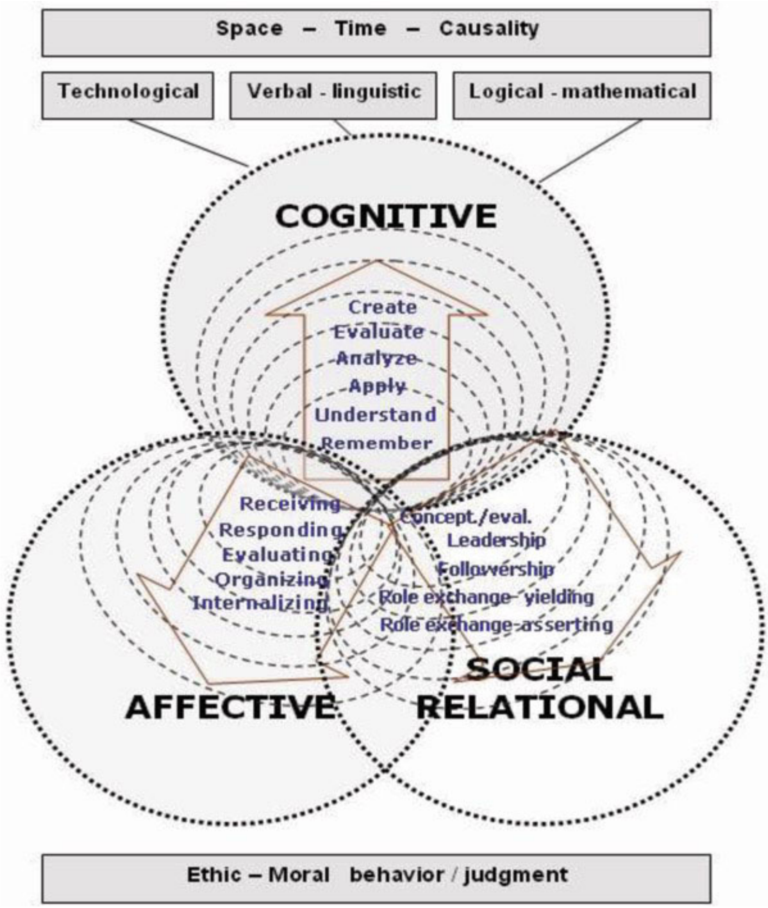

Fig. 2 The digital competence assessment framework

For the European Commission, the development of digital competence is based on the confident and critical use of Information Society Technology (IST) for work, leisure and communication and is underpinned by basic skills in ICT: that is the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet.

The above issues have led to the definition of work plans for the creation of suitable frameworks for digital competence assessment and the development of strategies helping students build sound digital competence. Among the most recent proposals there is one that is reported in Fig. 2 (Cartelli 2010). It is based on three dimensions (strictly related to well-known taxonomies): cognitive, affective and socio-relational. The cognitive dimension is the better analyzed and is made of three main sections: technological, verbal-linguistic and logical-mathematical (the last two mostly due to Gardner (1993)), all under the umbrella of the categories of space, time and causality (Piaget 1970).

It is behind the aims of this chapter the detailed discussion of all the features of the framework, but it has to be remarked here that cognitive dimension is very important in the analysis of people's ways of thinking and knowing. It can suggest hypotheses for the mistakes and the errors that people make in interpreting natural and scientific phenomena.

The Beaver competition, the international contest for the assessment of computing, logic and mathematical skills in the students of the 15 countries today involved in the same competition, has been used in 2009 by the author to verify the structure of the model, and especially the correctness of the structure of the cognitive dimension.

In the Italian experience of the Beaver competition, which has been held the first time in 2009, two different categories of students have been investigated: Benjamins (10–12 years old) and Juniors (13–15 years old). From the solutions the students gave to the different problems emerged very similar behaviours; in both cases, in fact, there was a relevant number of positive answers to single questions, but only 3–5% of the students gave the right answers to all the questions. More specifically, it could be shown that in both categories of students, less than 50% of them succeeded in managing the same information through different languages (i.e. the verbal and iconic languages), and may be 50% among them did not use space, time and causality categories of the cognitive dimension in the right way.

The above data led to the following conclusions:

- The structure of the cognitive dimension looked good enough to show that the students are differently skilled in each section
- The less developed sections and categories in the cognitive dimension are the possible reason for students' problems in knowledge development and in the acquisition of meaningful knowledge
- Sound teaching–learning activities can be planned and carried out to help students recover the gap in the underdeveloped dimensions and build the digital competences needed in the knowledge society

The main consequence of the above issues for the *InnovaScuola* project has influenced teachers' work by leading to the collaborative creation of at least two learning objects:

- The first one centred on binary logic and its use in the research and affordability of information
- The second one focussed on the representation of reality (i.e. texts with different subjects and actions) by means of different languages (especially verbal and iconic) and on the use of instruments and strategies for the hitting of this target

Both of them have been developed by teachers in the second part of the project and the corresponding LOs have been made publicly available on the Internet (http://elf.let.unicas.it).

Conclusion and Future Work

The above issues led to the following remarks, especially centred on to the instruments proposed for the *InnovaScuola* project and the definition of strategies and processes for teaching innovation. On the side of the instruments proposed for teachers' training the following elements were judged by teachers very positively:

- The framework centred on the integrated e-learning environment (i.e. the model based on WBL and CMC), which has proven very successful for the proposal of materials and the development of the activities in the project
- The Open Source instruments were considered very useful and would have been adopted for everyday work by the teachers
- The framework for digital competence assessment, and especially its cognitive dimension, which has been considered very useful to discover undeveloped or less developed languages and skills in the students

As regards the processes experimented in the teachers' training activity the following issues emerged:

- The use of the integrated e-learning environment was considered useful for the introduction of deeper innovation in the class work, but adequate help was needed from teachers for the management of the e-learning platforms and for the use of social networking instruments
- The lack of instruments involving students and families in the continuous monitoring of school processes and in the updating of students learning and educational data, was considered negatively affecting the evolution of teaching-learning activities
- The planning of teaching activities based on problem finding, problem searching and problem building, has been considered essential for students' successful learning (i.e. for their direct connection to the development of problem solving features); the hypothesis underlying this issue is that contextual and situated learning can be reconciled with scientific/discipline learning and, what is more, students can be helped in the overcoming of the problems they usually show when approaching scientific knowledge

What has been reported in the above issues has also been considered a very good basis for future development. It is especially true for the possible influence of problem solving based teaching on the development of students' autonomous strategies and ways of learning.

The main topics considered here are Personal Knowledge Management (PKM) and Personal Strategic Thinking (PST), both strongly based on digital technologies and skills. As showed by the scholars who introduced the first definition at UCLA and Millikan University (Sorrentino 2008), the instruments and the information skills that people need for retrieving, storing, analyzing and more generally managing information, can help them in improving individual's performances and intra-personal/inter-personal relations. Furthermore, it has to be noted that

Table 2 Basic features of personal strategic thinking (PST)

Elements to be considered for corporate strategic thinking	PST
Competencies and skills	Competences, know how
Products and offerings	Subject's specialization and capabilities
Environment and industry	Communities/society the subject belongs to, behavioural/ personal features, knowledge/communication features
Markets and customers	Knowledge sources/clients
Competitors and substitutes	Internal and external sources and conflicting needs must be compared
Suppliers and buyers	Subjects' specialization within the community and ability in supporting other people in the community

the instruments and the tools that people use for PKM, rarely motivate the actions that people undertake, not necessarily imply the thinking about the processes people are involved in and, what is more, do not help the creation of knowledge management strategies. For those reasons, the application to subjects of the ideas developed for corporate and firms on strategic thinking have been hypothesized (Cartelli 2008).

Table 2 reports on the right column the translation and application to subjects of the well-known features of corporate strategic thinking. Furthermore, the features of the processes that corporate must carry out can be applied to subjects; that is, they must be *aligned, goal-oriented, fact-based, lying on broad thinking, focused etc.*

The questions to be answered in further studies become:

- How much digital competences are useful for the development of PKM?
- How much digital competences can influence the development of PST?

Otherwise stated, if it is true that further studies are needed to better analyze the features of the framework for digital competence assessment and the relevance of the impact of LOs introduction on students learning, they have also to analyze the influence they can have on the development of PKM and PST.

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