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Instructional Design in Science: Using Scenarios in E-Learning

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Abstract: *The article discusses the place for ICT and its contribution to the teaching and learning process, mainly how to build a logical pedagogical approach by integrating ICT. It provides an analysis of a pedagogical scenario, then addresses the question of the status of the ICT in science teaching today provided with examples on its use. The article starts by discussing the dimensions involved in the conceptions of scenarios, and how to achieve a science education that emphasizes learning a scientific attitude, approaches and concepts, as well as a metacognitive approach. This involves collection of scientific data, reflection and metacognition, representation and modelling as well as communication. The real dangers concerning science education are therefore at the level of pedagogical usages to be developed by teachers. The researcher concludes that what should be changed first and foremost, are the representations about science education and their relation to scientific knowledge.*

Keywords: *Instructional design, scenario, science, e-learning.*

1. INTRODUCTION

Since the advent of information technology and communication for education, teachers, pedagogues and educationalists lead a reflection on their status in teaching and learning (Bransford, Brown & Cooking, 2000). This reflection increases further with the development of distance learning or online learning. The integration of ICT in teaching/learning has two fundamental backgrounds: didactic approach and practical approach that are influenced by behaviourism and constructivism. Modern instructional theories (Ausubel, Novak and Hanesian, 1978) argue for « active » and « rich » pedagogies which originate from socio constructivism and situated learning (Lave and Wenger, 1991) and use strategies like problem-based learning and inquiry-based learning. In such active methods, the teacher has to design, to facilitate and to monitor students' activities. Bransford et al. (2000) reported that" what is known about learning provides important guidelines for uses of technology that can help students and teachers develop the competencies needed for the twenty-first century" (p. 206). Several advantages for the integration of ICT were cited in the literature:

- Captivating tools, full of colourful images, audio sources, websites...
- motivating, since by combining text, image and sound they provide students the opportunity to discover the surrounding world,
- allow individualisation of learners, where actions are adjusted according to the physical, mental affective and social conditions of each student,
- give each student an autonomy, hence preparing students to be self directed learners,
- allow interactivity, maintaining real conditions of communication,
- Cognitive tools, as they affect the way students construct their knowledge; they offer the possibility to establish learning situations that allow collaboration and interaction (Gillepsie, 2006; Murphy, 2006).

Therefore, using ICT in classrooms answers to the pragmatic needs as well as the pedagogical needs of students. But it is important to ask: What place is there for ICT? What is its contribution to the teaching and learning process? How can it be linked to a particular teaching approach? How to build a logical pedagogical approach by integrating the ICT?

Moreover ICT integration in teaching and learning faces a lot of challenges. On the first hand, there is no specific framework for using ICT. Added to this is the lack in teacher training and professional development regarding the use of ICT, and teachers' fears towards the challenges this usage imposes (Becta, 2004). Hence it is not enough to create new tools in order to have very promising work. It is important to reflect on the way of using those tools as well as the conditions for their proper implementation. Teachers need help by showing them the correct ways to use ICT in class. As part of the search for coherence in the teaching-learning situation with new technologies appears the notion of pedagogical scenario. This paper provides an analysis of a pedagogical scenario, then addresses the question of the status of the ICT in science teaching today provided with examples on its use.

2. THE "SCENARIO" AS AN INSTRUCTIONAL DESIGN MODEL IN THE CENTRE OF THE EDUCATIONAL PROCESS

A Scenario is defined as outline of a play or a detailed description of the different scenes in a film (Cf. Merriam Webster dictionary, 2010). Hence it refers to a plan of action or learning context for the accomplishment of a specific action. In an educational context, this term applies most often to plan a unit or a lesson by the teacher - or by the designers of a textbook. This is a programmed educational project designed to meet the profits of learners by facilitating learning with technology. It describes the discipline, theme, objectives, target audience, activities, pre-requisites and, in more detail, the objectives of activities, the roles of the student, tools, resources, phases, evaluation and possible suggestions for reinvestment. It is worth mentioning that the notion of pedagogical scenario occurs frequently in relation to the Information Technology and Communication in Teaching (ICT), such as in the definition given by Schneider et al. (2003):

"A pedagogical scenario is a sequence of phases within which students have tasks to do and specific roles to play. In other terms creative but flexible and open "story-boarding". While teachers can regulate and orchestrate complex scenarios with very little technology the effort can soon become cumbersome. In addition, more advanced functionalities like visualizations of student activities can simply not be done without the help of technology. This implies that modern and active pedagogy is more successful if the teacher can profit creatively from information and communication technology (ICT) according to his and his students' needs. The scenario occurs in a project, or any particular learning activity, and requires internet resources as well as radio, television, online and multimedia.

Puren (2002) distinguishes pedagogical scenarios related to educational projects, scenarios centred on didactic units or lessons, and evaluation scenarios. Probably the best known example reflects a shift away from the educational legacy of 'exemplary scientific practice' within the school curriculum as characterised by real experiments (Gooding, 1990) towards a more 'naturalistic philosophy' – that people learn by active intervention in a concrete world (Giere, 2002) where tools such as simulation and animation may play a bigger role.

The pedagogical scenario in this case is a way intended to help teachers in their classroom practice. However, another scheme of pedagogical scenario is possible: one where the recipient is not the teacher, but the student himself. In this process the learner can, due to the detailed description of the learning scenario, identify objectives, prerequisite skills and resources and tools requirements. Interaction and support must be provided during the implementation of the activities and tasks.

Hence, a pedagogical scenario becomes the customization of a path with staggered progressive steps and activities which must be done by the learners and the tutors, the sequencing of these activities as well as the learning objects and tools that should be provided to the different actors with proposed mode of organization (such as the role played by different actors), and instructions describing the outcome. This type of scenario can be included in a larger category which provides activities, support and other resources. It is preparing, and developing a product of interactive multimedia by addressing content, actors and processes (Jaudeau, 2003).

It is worth to note that instructional design integrating ICT imposes several problems that can be technological (students' knowledge, availability of materials,) organisational (students' participation, availability of computer labs..) pedagogical (new roles of teachers, students, evaluation...) or institutional (finance, ...). The production and use of pedagogical scenarios should be backed by providing support for pedagogical scenarios at both organizational and technical level (Brassard & Daele, 2002); hence different dimensions are involved in the conception of pedagogical scenarios.

3. Educational Orientation and Choices

The design of teaching and learning continuum varies between the instructivist (or behaviourist) approach in which the role of the teacher is very explicit and the technological environment is designed for easy access to information, and the constructivist work environment that facilitates the exploration, research information from multiple sources, synthesis, manipulation objects, etc.). Orientation goals to the activities can be centred on very specific goals or can be related to general fields of study. In this perspective, consideration of errors continuum varies from a scenario that tolerates no errors where teachers identify learners' errors and make appropriate feedback to another scenario that encourages learning experiences and where teachers propose opportunities to experiment and implement authentic knowledge. Such scenarios are controlled by the flexibility of the device which could be fixed and synchronous working tools or could be open environments such as asynchronous work in a virtual environment.

3.1. Actors and Roles

The role of the teacher could vary between merely teaching, such as the acquisition of specific knowledge by learners, to facilitator, where tutoring may take the form of content expertise or technical assistance. Learners' motivation can be extrinsic where teachers prepare innovative and original activities or intrinsic where activities are centred on learners' own projects, their prior knowledge and their professional and personal goals. Individual differences of learners can be taken into account or not depending if planning shows consistency in cognitive styles, affective factors, previous knowledge or can recognize individual differences where teachers offer alternative paths based on individual needs. Planning of those scenarios might involve participation to a network or communities of practice, where students become active members in their professional community.

3.2. Activities

The tasks can be academic where teachers give comprehension or application exercises, or can be designed as authentic learning activities based on real life situations and research. In these learning activities, students can have access to content or teachers might offer opportunities for students to create processes for developing knowledge with appropriate tools. The strategies used can be based on individual work or cooperative learning environments. The evaluation of learning can be a continuum that varies from traditional assessment based on oral or written examinations to participatory assessment such as self or peer evaluation.

3.3. Tools and Processes

The control by the learner can be completely absent from such designs or learners can be completely involved in choosing tools for learning. Some pedagogical scenarios can integrate support tools for reflection such as logbook, portfolio that encourage metacognition. Knowledge management can take several ways such as complete or partial access to community, networks, as well as different methods of production, exchange and reuse in other fields of knowledge.

4. ICT in Science Instruction

There are different usages of technology in science education. Too often, ICT is only a facade of technology on already existing learning activities, a façade that is not always relevant. However, recent technologies can truly add value for the development of unit and lesson plans.

A bias in the use of ICT is to consider the Web as an inexhaustible reservoir of knowledge. Many teachers ask their students to "seek scientific information on the Internet" and make a summary (Saleh, Abu Baker, Mashhour, 2011) [13]. This representation of scientific knowledge results in a prejudice to the teaching of science, since in this way, students will consider scientific knowledge as "external" and fixed, and that learning is the transfer of this knowledge called declarative from the computer screen to the brain of the learner, by a simple transfer. Similarly, watching a science video only reinforces the same representation. To fight against this representation, and therefore to achieve a science education that emphasizes learning a scientific attitude, approaches and concepts, as well as a metacognitive approach (Giordan, 2001) [14], it is a radical to stop such practices.

Technologies enable this change mainly by promoting activities integrating ICT and assistance in:

- collection of scientific data;

- reflection and metacognition;
- representation and modelling;
- Communication.

4.1. Collection of Scientific Data

Doing science is confronting one's conceptions and explanatory models, to real cases, that is to say, to the information from our surrounding world (Duschl, Schweingruber, & Shouse, 2007) [15]. Students often collect data that is related to their perception of the world.

Different technologies allow to collect these data and to keep them for further processing (Hennessey, 2006) [16]. For example, the camera will show the stages of transformation of a caterpillar into a butterfly, the position of the sun at certain times and in certain seasons, or the key moments in the germination of seeds. In addition, many scientific institutions make their databases available to users on the Internet.

Science Teachers have a long history with the use of ICT. Once the rooms are adequately equipped, the use of ICT becomes often real and relevant. In high schools and some middle schools, teachers practiced computer assisted instruction for more than ten years now. The new programs encourage the use of ICT tools for: word processing, spreadsheet, graph, presentation tool, simulation, ExAO (probes), animations, ...

However, although science teachers fit very quickly and naturally the new tools offered such as projector, digital interactive whiteboard, computer- assisted instruction and which act as conversational artefacts (Pea, 1993) [17], inspectors and coordinators focus on the appropriateness of the use as well as the benefits of those artefacts. Thus, along with recommendations on a "quantitative use ", training and inspection interviews insist on "quality use". According to Kozma (2008) [18], the surface features of the scientific representations such as colors, lines in graphs can support students' processes of appropriation, negotiation and convergence towards shared understanding.

In middle and high schools, ICT is used to:

- make documentary research on the internet (history of science, ...);
- write a report, presentation or prepare a computer-assisted presentation of an experiment in class or outside school hours;
- perform an experiment by taking measurements and recording data;
- use digital data from an experiment using a spreadsheet;
- simulation of experiments that cannot be done in the classroom e.g. the effect of a short circuit on a domestic power supply, changes in kinetic energy and gravity in free fall (in college), change the parameters of an orbit ...
- use a video for the study of movement: a falling body, energy study of the relativity of motion (Kearney & Schuck 2005) [19];
- develop an understanding of physical phenomena by solving online exercises (quizzes, ...) ;
- help understand some physical laws using interactive software, simulating phenomena and representing the evolution of the variables

Some examples of using ICT in sciences are:

- **The interactive whiteboard (IWB): easier navigation**

From a home page, the teacher can open various applications (sound, images, software, animation, video, another page, Internet) that allow nonlinear development of the course and the easy and direct access from the board to a multitude of resources.

Students use IWB to make experimental records. They can simply access a picture of the setup, an online exercise (via a hypertext link) and can use the board to enrich the content of the lesson. The teacher can, using the software associated with the IWB, keep all records produced during the session. These are various: explanations, comments, suggestions for students, comparisons, correction of exercises.

It is quite possible to "return" to previous pages for explanations, exercises or notes. These written records allow the teacher to reactivate the students' memory and remind them of what was exactly studied previously. However, teachers must be careful about the amplifying effect of the tool in the use of applications. Educational choices are crucial to ensure that the wealth might harm the construction of a structured learning.

- **Students' response clickers system**

Still uncommon, these tools are used on an experimental basis by some teachers. A batch of 30 boxes is required for use in the classroom.

Some of their recognized uses are:

- Diagnostic evaluations.

At the beginning of the chapter, the results of a diagnostic evaluation are recorded and provide access to the response of each student.

- Formative evaluations.

The teacher, at the beginning, during or at the end of the session, asks some questions about what has been discussed with students. They indicate the level of acquisition and understanding of new knowledge and skills.

- Corrections of exercises.

These tools are used to assess the effects of remediation following a correction of homework duty and extended by some differentiated activities.

- **Digital viewers**

A digital viewer can project on a screen a desktop program, a textbook page or student notebook. The projection of a student notebook or work done by a group can initiate a collective exchange and debate. The image can be stored and used later.

The projection of measuring instruments, experiments or displayed values can also be used in supervised homework.

- **Data acquisition systems with or without video**

Some common examples of using an acquisition system associated with a spreadsheet-graphics:

Recording an AC voltage to address the study of periodic voltages;

Determining the characteristic of a dipole;

Measuring the speed of sound

Experiments on the relativity of motion

Variation of temperature during the change of state

The use of digital videos gives teachers and students sophisticated tools to observe dynamic processes in intricate detail. Videos can overcome the traditional barriers by showing difficult, expensive and time consuming experiments (Hardwood & McMahon, 1997) and allow students to observe accurate and reliable replications of demonstrations. Videos can create the illusion of speeding up or slowing down, or real life events to make science more relevant to students' lives (Fuller, 2000).

Computer digital video systems allow students to capture videos of experiments and later use them to analyse and model their data using spreadsheets. Such video based laboratories are perceived to facilitate constructivist learning environment by promoting open ended exploration in an authentic learning environment (Squires, 2003) [22].

- **Simulation tools**

Many simulation tools - free or paid - are available to science teachers. They allow the creation of virtual experiments that can only be done in the classroom, such as the effect of a short circuit in an electrical installation.

They also help to understand the laws of physics (such as the vector formulation of the 2nd law of Newton)

- **Internet**

The internet is a wealth of information and its use by teachers depends primarily upon the class. Thus, in middle schools, navigation is oriented to prevent wandering and complete information should be provided on the dangers of web. In high schools greater use of free research but navigation to target sites is still widely used. Netiquette, social conduct on the net must be taught and respected.

4.2. Reflection and Metacognition

Metacognition is namely defined as knowledge about knowledge, knowledge on how we are thinking at the moment, and control over our thinking (Kilpatrick 1985). It refers to the processes that allow people to realize what they know and how they know it, in other words, the acknowledgment of the learning process. Hence metacognition refers to learners' views and beliefs about learning as well as to the active regulation of their learning process.

"Learning science means that the student is not only" active "(using hands), but also" author "(using head)! "(Giordan, 2008). In addition, the role of metacognitive reflection on learning is well established (Lebrun, 2002). In this regard, the technologies used, for example by asking students to photograph or film the different stages of an investigation, allow an a posteriori reflection on the approaches and activities used by the students.

By being active, the task is then to question the skills to succeed in mobilizing activities and strategies implemented by students to carry this out. A personal blog or class blog can serve as a testimony to institutionalize certain strategies and steps taken.

Another advantage is the possibility for the students or the teacher to keep records in the form of photos, for example, for students' achievement; this could be for the experimental setups they might design or for the results of their investigations (panels, ranking Object, ...).

Metacognition is a key element of learner self regulation, where students activate and sustain thoughts, behaviours and affects which support the attainment of their goals (Schunk & Zimmerman, 1998). Metacognitive approaches entail supporting learners to be aware of the knowledge and skills they do or do not possess, and to use appropriate strategies to actively implement or acquire them. In contexts of rapid change and unfamiliar content domains, such as are inevitable with technology, this understanding of 'how' to learn provides distinct advantages.

4.3. Representation and Modelling

It is tempting to use, in science teaching, different types of representations that facilitate meaningful understanding of scientific phenomena. A lot of scientific encyclopaedias offer explanatory diagrams. Many companies offer editing videos, CD-ROMs, multimedia animations in every scientific subject. However, the use of such representations should not only help understanding but also prevent or even consolidate or create misconceptions.

For example, most representations of the revolution of the Earth around the Sun induce misconceptions about the size of the Earth and the Sun, or about the Earth-Sun distance!

However, judicious use of videos, pictures, flash animations, diagrams or texts attempting to explain a natural phenomenon may be the bearer of learning, provided that teachers are aware that simply viewing the proposed activities is not sufficient to induce learning.

One can, for example, ask students, after working on certain scientific concepts, to look at an extract from a video session of 4 to 5 minutes, but without sound (mute). Students' task is to make a comment on the sound images. Flash animation on breathing will make connections between what they see and diagrams or photos of the same object of study. A diagram can be used to support the production of a caption or a comment. Those examples justify that any task performed by the students using various technological tools can represent a learning opportunity.

It is important to highlight the specific usefulness of featuring certain digitised content within a platform such as the content created under SCORM (Sharable Content Object Reference Model) standards. It is possible to create structured pedagogical objects with the advantage that they can be reused, transferred to other platforms, updated, and so on.

4.4. Communication

Along with the constructivist paradigm of teaching and learning, students learn through interaction with their classmates as well as their teachers; they construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences; hence feedback is a fundamental factor in the final acquisition of the content. Technologies can facilitate further interaction thanks to the use of blogs, forums or social networks. As stated by Baker, De Vries, Lund and Quignard (2001), the epistemic interactions provide a means to understand the problematic nature of tasks, develop critical thinking and stimulate the desire to learn. It is at this level that the web resources can be an asset, for example to compare the different findings related to the same concept.

Nowadays, platforms such as Moodle are based on constructionism and therefore feature a structure that facilitates the production of learning. As Davis (2005) [28] says, the Web 2.0 "is not a technology, but rather an attitude"; it is the transition that has occurred from traditional applications to applications that really work. To 'moodle' is the practice of enjoyable tinkering that often leads to growing knowledge, insight and creativity. This applies both to the way Moodle was developed and to the way teachers may use it to teach and learn.

Through end-user-centred websites, special line of services such as social networks, blogs, and wikis can be used. Wiki is a tool that enables the creation of content in a collaborative manner. A wiki is useful in a training environment due to the ability to create joint documents for an assignment. Content can be created, modified and deleted by different users, and thus, as a learning tool it has very high pedagogical benefit. A blog, unlike a wiki, is more of a personal site, with information organised chronologically, in which teachers and students can create, with the intention that their colleagues will read what has been created. Colleagues can give their opinions on what is written, but cannot modify the original text, which is the main difference from a wiki.

There is also a new tendency within the e-learning world to talk about connectionism (Siemens, 2006) [29], which is a learning theory for the digital age that attempts to explain the effect that technology has on the way we currently live, communicate and learn. This theory begins with the individuals, who obtain all their information from a network that is continuously receiving feedback; this new information makes the previous information outdated. The critical skill is in being able to distinguish what information is important and what is insignificant. In this regard, this theory comes together with the new technologies of the digital age, where the information flows from multiple points and where it is crucial to know how to differentiate the essential from the trivial.

5. CONCLUSION: TOWARDS TRUE INTEGRATION OF TECHNOLOGY IN SCIENCE

We see it every day; technologies are radically changing the access to information and media. E-Learning has been spotted as the solution to the growing needs of education. All scientific phenomena are to be explained, either in online encyclopaedias, in popular science sites or Web pages. Many televisions are also available to display videos related scientific topics. However, a lot of teachers still consider that the consultation of documents, like reading science books, provides a real science education that is capable of developing a scientific attitude and skills and to build lasting scientific concepts.

The real dangers concerning science education are therefore at the level of pedagogical usages to be developed by teachers. Indeed, which relation to knowledge emerges from this mass of scientific information stored on the Web? Scientific knowledge is doubling every ten years; it is illusory to know everything. In addition, this knowledge is evolving! What was accepted by the scientific community ten years ago is no longer accepted today.

What should be changed first and foremost, are the representations about science education and their relation to scientific knowledge. Teachers must realize that all scientific information published on the Internet is only a partial and biased representation, and an explanatory model produced by the author; they must also be aware that science learning does not mean trying to transfer the knowledge displayed on the computer screen to the minds of learners. New skills are needed to manage, analyze and process the multiplicity of data.

Today, technology is constantly evolving at an incredible speed. New opportunities for communication and information processing (data, still and moving images, sounds, drawings, information systems,...) and new technology are emerging every year. This allows easier access to scientific tools.

Many institutions and enterprises have set up Learning Management Systems (LMS) and organized their work around these new technologies. However, when the number of learners grow, it becomes difficult for tutors to support them correctly while still being aware of individuals that need some special care because they experience difficulties. Instructional design is a widely-acknowledged system of planning, implementing, and evaluating instruction (Gagne, Wager, Golas, & Keller, 2005) [30]. To plan lessons or units in digital learning environments is to design a sequence of activities that will be presented depending on the behavior and actions of the learner. Some instructional design models incorporating technology integration include the Reiser and Dick model, the ASSURE model, the Teacher Decision Making model, which gives explanation to the ADDIE process (Analysis, Design, Develop, Implement, and Evaluate), and the Kemp model.

Educational institutions are facing a triple challenge. First, they must adapt to technological innovations by investing in educating and training teachers as well as in technological equipments in schools. Second, they must gradually reorient teaching content, devices and practices to take account of the evolution of science education, and the contributions of new technological tools. Finally, they are forced to engage in a real media education and technology, mission somewhat left behind at the end of the last century.

Issues mentioned in this article are only a first step for teachers and their students to take into account technological developments in the teaching of science, and to develop an investigative approach that is emphasised in the curriculum but is actually little in practice. In technology integration, scenarios depend primarily on the type adopted: face to face (using slides, simulation), hybrid mode (some modules of distance learning, or presented in the form of micro -learning) or totally online (online learning environment with a virtual campus and virtual classroom generally leading to a certification system). Scenarios can be at different levels: a simple activity, or planning units by the above-mentioned model. In the case of online courses, educational structure is based on three systems: input system (objectives, test prerequisites) learning system (ownership of content through consulting resources, performing exercises, research and individual or collective production, etc.) and output system (post-test for the final evaluation and certification). For each system, the scenario must specify instructions through the tasks of teachers and those of students before, during and after each learning activity or assessment.

To conclude, let's say we have an interest in adopting the teaching scenario to align learning and teaching activities. Teachers are sometimes reluctant to engage in designing scenarios due to concerns about the amount of time needed to address the instructional planning issue. Many fear that too much time allocated for instructional design may take away from the instructional time for teaching content. However, models and tools used in instructional design can be shared through space sharing forums and web 2.0. Small independent learning sequences or demos are produced and shared among teachers; animations / simulations can be combined in various forms.

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