Novel Pedagogical Paradigms facilitating mixed mode and collaborative learning using open source software[1]

N.Alexandrov*, R. Ramirez, V. Alexandrov***

* Centre for Advanced Computing and Emerging Technologies
School of System Engineering
The University of Reading
Whiteknights, PO Box 225
Reading, RG6 6AY, UK

**Department of Computer Science
ITESM, Monterey Tech,
Monterey, Mexico
{n.s.alexandrov@reading.ac.uk, rramirez@itesm.mx, v.n.alexandrov@reading.ac.uk}

Abstract

E-LANE consortium has chosen the information technology mediated distance learning technology. This technology combines the large audience and large geographical coverage of traditional tele-education with the advantages of computer based learning, such as multimedia resources, and improved navigation, visualization and interaction. Moreover, the use of the Internet and its related technologies as a means of information and data transport, and the reuse of learning objects and educational information via international standards such as SCORM (ref) and IMS (ref) will allow the consortium to achieve its objective while keeping the associated costs reasonably low.
The E-LANE Project

E-LANE is a consortium, constituted by educational institutions and enterprises from both Europe and Latin America that aims to reduce the digital divide present in our societies by developing an education program that uses advanced teaching methodologies and paradigms, as well as open source telecommunications and information technologies. At its core, E-LANE uses Internet technology mediated learning, from web pages, sites and applications, to document transfer and instant multimedia communication applications. The immediate goals are:

- To develop pedagogical models that will allow the creation of educational programs that can adapt to different needs, environments and audiences
- To develop high-quality, low-cost distance-learning technology such as learning management systems, courseware integration tools and learning evaluation platforms

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- To develop effective course, activity and evaluation design methodologies that will allow efficient learning as well as long-term retention of knowledge, abilities, competencies and skills
- To develop innovative courseware design guides and establish readily-applicable criteria which will allow the integration of technology, courseware and activities in different ways for different audiences and environments in order to enhance learning

E-LANE chose information technology based learning, which we will now call e-learning, because it poses the following advantages:

1. Eliminates space and time barriers.
2. Reduces costs and allows the results of the project to be replicated and thoroughly spread.
3. Widens the reach of the benefits of high quality education even to those that by reason of their geographic isolation, their family/social situation or they economic constraints cannot have access to it.
4. Improves the efficiency of the learning process in such a way that education can take place in a shorter amount of time
5. Improves the effectiveness of the learning process by achieving a high transferability of skills from the learning environment to real life and usefulness over a longer period of time.
6. And in general, it promotes the information society (e-learning, e-government, e-health, e-economy, e-science, e-inclusion), which by means of information technology, aims to create a better society where goods and services reach equally all citizens.

This document describes the educational framework of the E-LANE project. The rest of the paper is divided as follows.

E-LANE Educational Metamodel

In order to achieve its goals and guide the development and implementation activities, E-LANE has developed a theoretical framework of the learning process. We call this framework E-LANE's Educational Metamodel because it establishes certain variables that once an educational program with specific needs instantiates, it produces a unique educational model for such program. E-LANE's educational metamodel has the five components shown in figure 1 and described below.

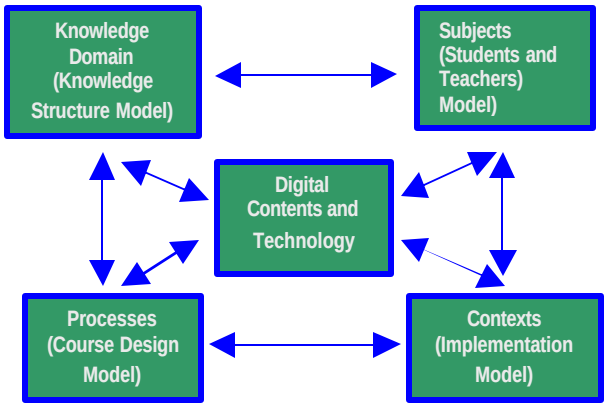

Figure 1. E-LANE Framework: educational metamodel components

1. **Knowledge domain**. This not only describes the knowledge that we desire students to acquire, but also certain different skills, which can be cognitive, affective and motor. That is to say, that this component represents the main goals and objectives of the educational process. Cognitive skills enable students to correctly mentally organize knowledge so that it can be selected and used effectively, to differentiate or induce knowledge such that it can be applied in different contexts, or to integrate knowledge or deduce knowledge so it can be restructured to fit new situations. Creativity, the ability to create new knowledge is also an important part of the knowledge domain and should always be considered as part of the educational program. Affective skills enable students to work collaborative in teams, to respect different beliefs and cultures, to respect the environment, to strive for self-improvement, to self-learn when required, to be proactive and entrepreneur, to be honest, etc. In this category are usually included other soft-skills such as attitudes and values like honesty, responsibility, capacity to work under pressure, aesthetic appreciation, love of nature, respect for diversity, etc., the meaning and selection of those is completely locally defined. Motor skills, can be considered exactly that, especially when we are dealing with physical training of some sort (small children, heavy equipment operators, etc.). But it can also mean the sort of skills required to install, configure and administer technology, to learn laboratory procedures or be proficient in difficult techniques like those social workers must use. This latter group is usually referred to as procedural skills, and together with the associated knowledge are usually called competencies. It is important to point out that knowledge by itself can also be classified, according to some authors [1] as conceptual, procedural and metacognitive. This classification is important, as students must construct knowledge in increasing phases of complexity. When information technology is involved, other skills will be acquired by students such as ability to work in different scenarios with different types of information, the possibility to use different information channels to interpret phenomena, ability to communicate synchronously and asynchronously, ability to take responsibility in decision making, ability to refine information selection criteria, etc.
2. **Educational subjects**. It indicates the nature and origins of students and teachers and the relationship between them. It is important to recognize the age group, academic background and other culture related information about students. Effective learning is achieved when the process is focused on student's interests, culture and environment, and when new knowledge and skills is constructed upon a well identified academic base. The location and available resources to learners in such location is also very important as it will influence which learning activities students can carry out. The relationship between teachers and students is also important. Learning can be a self-directed experience where the teachers role is more that of a tutor than that of an authority. In such a relation, students have a large degree of control on their learning

and power is more balanced with that of the teacher. On the other hand, learning can be a much directed experience, as in more traditional learning. In this case, teachers have most of the control of the learning process as well as most of the power. Self-directed learning experiences mediated by information technology (distance learning) require more planning and material preparation from teachers. The former, because some teachers do not have direct contact with students so they must guess and estimate student progress and emotional estate. The latter, because information technology tends to create a sense of isolation. Students must by themselves confront their own ghosts of incomprehension and isolation. Thus materials, tools and the learning process as a whole must be very easy to use and understand.

3. **Contexts and environments**. They establish the variables that make-up the virtual learning space. The same knowledge domain may be taught to different people with different culture, in different locations with different resources, and at different times with different emphasis, by different teachers with different types of communication. Thus the analysis of contexts tries to identify those variables and how they affect learning in order to be able to reuse as much as possible the already developed activities and materials and to make the learning process more effective. Once those variables are identified, old activities and materials may be used, or new ones may be developed. Contexts are very important, as the most effective materials and activities are those that focus on the student's background, interests, culture and environment.
4. **Educational processes**. In general, this term identifies the activities that must be carried out by students in order to acquire skills and knowledge. Those activities are usually designed following certain philosophies such as conductism, cognitivism and constructivism. They take into account the knowledge domain, student's background and learning contents. Those activities may be such as searching, reading, viewing videos, hearing audio, dialog and discussion, drill and practice, problem solving, research, quiz solution, reflexion, write essays, etc. They are structured in such a way that students progress from simple to complex knowledge and skills, to knowledge creation. They are varied enough so students can use different channels to acquire knowledge depending on the inner workings of their brain and body. Also, different paths can be taken in order to achieve learning goals. Constant feedback and evaluation is carried out, and different students may achieve learning objectives at different speed.
5. **Digital contents and technology**. Also based on the knowledge domain, student's background and the learning context, digital contents and technology are closely tied to the educational processes for basic learning activities are carried out using them. Digital contents and technology must endeavour to target as many communications channels as possible as well as students' different intelligence capacities such as linguistic, visual, kinaesthetic, musical, logical-mathematic, interpersonal, etc. Digital contexts vary according to the type of knowledge they support; conceptual, contextual and procedural. For example, we can use graphics and 3D animations to show the meaning of certain concepts and the relation between entities and components. We can use video and audio to show procedures and human interaction. We can use interactive simulations to help understand how different environments modify a system's behaviour under certain contexts, etc. But digital contents not only need to support knowledge acquisition, but also cognitive skills, attitudes and values. This

can be done by showing different scenarios and different outcomes to carefully planned hypothetic situations and by promoting conversation, argument, debate and discussion. This is usually carried out through a special technology, a software program called the learning management system (LMS). The role of such system is to support file storage and delivery, information sharing, communication, planning, statistics recollection, discussion and dialog, assessment and evaluation for individuals, and all that plus collaboration for teams and groups. Some times all that support is carried out by one integrated platform such as Learning Space, Blackboard, dotLRN or Moodle. Some times different platforms are used, such as and FTP server, and a Web server, e-mail and instant messaging.

From these components the following models arise which characterize the educational environment of the E-LANE project:

- **Knowledge structure model**. It derives from the **knowledge domain** component. It can be called also the **general learning process model**, as opposed to the specific learning process model determined by learning activities that we will specify later on. This model determines the general process to be followed, the cognitive classification and the level of difficulty of the learning objectives based on certain assumptions on how knowledge is acquired, stored and structured by the human brain. It is more thoroughly described in section XXX.
- **Learner model**. It derives from the **subjects component**. This model establishes students' background, origins and learning location with associated resources. Although simple, this model is very important as learning activities should focus on student's **interests, environment, background and culture**.
- **Instructor model**. It derives from the **subjects component**. Also very simple, this model established the instructor role in the learning process and the relation between learners and instructors. Instructors' role can go from traditional lecturer to facilitator and tutor. Also, there might be more than one instructor in a given course, thus it becomes necessary to establish each instructor's responsibility.
- **Technology platform model**. It derives from the **digital contents component**. It establishes what support will be given to learning activities by way of technology and how they relate to the learning objectives and other digital materials.
- **Implementation model**. It derives from **contexts component**. It establishes the value for certain variables that define a course, for example, location, resources, characteristics of students and teachers, time synchronization and depth, etc. It ties the learner, instructor and platform models together.
- **Content development model**. It derives from the **digital materials component**. It established the procedure which will be followed to develop the digital materials and how they relate to the learning objectives and to the learning activities in the form of learning objects. It also establishes the technology to be used in each learning object and the ways and means to deliver those materials.
- **Course design model**. It derives from **processes component**. It can also be called the **specific learning process model** or the **learning activities model**. It establishes the learning activities to be carried out by students in relation to the learning objectives and the learning objects. Although there is a very tight

relationship between learning objects and learning activities, many of the learning activities will have nothing to do neither with the digital contents nor with the learning platform. For example, students may be asked to rehearse certain skill, to prepare charts and graphs, to read books, to go to the cinema to watch a movie or simply to converse with some one. Surely, if the activities do not make use of the course's digital contents, they may make use of the platform to create an evaluation and evidence portfolio, although this is usually not mandatory since written papers can be part of information technology mediated education.

- **Evaluation model**. It derives from **processes component**. Evaluation and assessment are different. Assessment establishes how far from the learning objectives students are. That is, if students must go from point A, the assumed knowledge accumulation for most students at the beginning of the learning process, to point B, where all learning objectives have been achieved, assessment establishes how far a student or a group has advanced. On the other hand, evaluation takes into account the process, including activities carried out and the speed with which the learning process has taken place. It is a global performance measure, while assessment is a knowledge gauge. When either assessment or evaluation is quantified it is called grading.

E-LANE's Integrated Knowledge Structure Model

E-LANE's Knowledge Structure model derives from the advances made by three other educational models: Genius Educational Model [3], ITESM Educational Model [4] and Robert D. Tennison's Integral Model for Computer Based Instruction [8]. The first two are constructivist, the third one is cognitivist. Each one has produced important contributions that make E-LANE's model such a complete one. For example, Genius' model divides knowledge into primary, secondary and tertiary and emphasizes the need of group support and knowledge construction through dialog, debate and discussion. It also emphasizes the need of addressing soft skills in learning. ITESM's model stresses the need of using different techniques for group collaboration and at the same time addressing the issue of teaching attitudes and values (AVs). Tennison's model addresses the issue of cognitive complexity and creativity while specifying guidelines of appropriate courseware and activities for each type of learning and learning level.

To produce E-LANE's knowledge structure model we start by observing that creativity and AVs are not that far apart. They both require complex rewiring of the brain linking present knowledge with new knowledge using new kinds of thinking and mental techniques. They also require the creation of new knowledge. They are both hard to teach but share several techniques for learning: conversation, argument, debate and discussion. They also have particular techniques. For example is well know that the best way to teach AVs is through example and field work, while creativity can be taught with experimentation (such in art), interactive design, and dynamic simulations.

The approaches can be integrated as proposed in [4]:

1. **Conceptual and contextual**. This is verbal and visual information which deals with the learner acquiring an awareness and understanding of the concepts, rules, and

principles within a specified domain of information. It also deals with teaching the student when or why certain rules and principles apply and the relation of these to other near domains of information. This is the **primary conceptualization stage**, and is mainly concerned with **information analysis**.

2. **Procedural and Problem solving**. This knowledge involves the learner acquiring the skills to correctly use concepts, rules and principles of a specified domain of information and also allows the construction of a mental knowledge base's organization and accessibility that enable the development of problem solving strategies, and creativity and attitudes to be developed later on. This knowledge aims to create in the subjects new **thinking strategies** for problem solving through differentiated (i.e., the ability to understand a given situation and apply appropriate criteria) and integrated (i.e., the ability to restructure knowledge in the service of a given situation) thinking. This is the **secondary construction stage**, and it is mainly concerned with **information synthesis** and **active learning**.

3. **Cognitive complexity**. This knowledge aims to enable students to use the full power of their **creativity** to solve problems, which do not conform to known patterns. Furthermore, it also endeavours to link all that knowledge through higher levels of thinking by reflection and discussion about knowledge, society and life, in order to imprint **values** and observable **behaviours** and **attitudes**.

Thus our new model looks like follows:

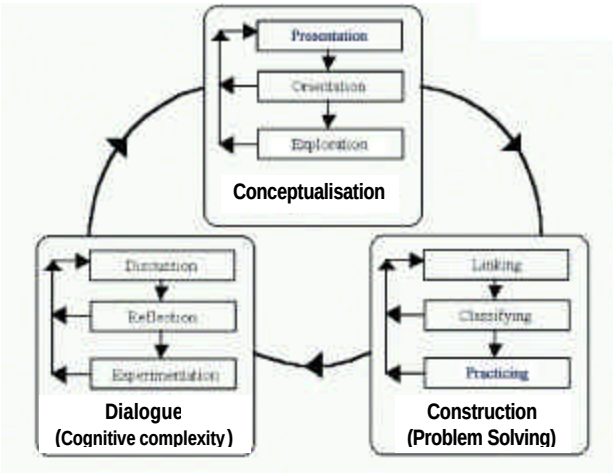

Figure 3. E-LANE Integrated Kneledge Structure Model

1. In the conceptualization phase, the presentation of information and the interactive exploration of the learning and virtual environments allows the acquisition of conceptual knowledge through memorization and comprehension. Teacher orientation helps students resolve questions and fears.

2. In the construction phase, students learn contextual and procedural knowledge by constructing mental structures that analyze, classify, link and relate different concepts and components of the knowledge domain. Drill and practice help to develop contextual frameworks of knowledge application.

3. In the dialogue or cognitive complexity phase students talk to each other, propose, argue, debate, hypothesize and debate solutions, ideas and new knowledge. They rewire their brains in order to develop problem solving strategies and creative thinking. They evaluate by experimentation and by creating mental models that predict behavior.

Implementation Model

As suggested by the learner, instructor and platform models briefly described and based on the extensive previous experience of E-LANE's partners in distance learning projects, a course is characterized as a record of eleven dimensions established by the following variables:

1. **Scale**: How many learners will be enrolled (one, a few, 30-100, thousands)
2. **Instructor**: Is the course a self-guided experience or is it a scholarly endeavor (none, a facilitator, a teacher, contents author, different instructors with different roles)
3. **Location**: Where will the main activities of the course will take place (classroom, home, community center, museum)
4. **Level**: What degree of qualifications will be required of learners (digital literacy, higher education certificate, higher education diploma, bachelor, professional skills certificate, professional skills specialization, masters, doctorate)
5. **Computing availability** (one computer, several computers, one computer per learner)
6. **Local network availability** (yes, no)
7. Internet connectivity (none, less than 56kbps, a modem per computer, broadband – 128 kbps or more)
8. **Synchronicity of communication** for text, voice, files, video (yes, no)
9. **Age** (children, young adults, adults, senior citizens)
10. **Platform**: an integrated LMS, an FTP site or a WWW site (e-mail, messaging, file storage and management, project management, assessment and evaluation, discussion forums, information portals, activity calendars, information editors, etc.)
11. **Main motivation**: Are participants self motivated by a need of personal improvement or are they compelled by their families or enterprise or government policy? (career enhancement, new technology at work place, change of regulations, law or procedures, school curriculum)

In the next section, we turn to the specific problem of implementing one of E-LANE's main goals: digital literacy in Latin America. Also, we will refer to E-LANE's technological learning platform as dotLRN (or rather a Learning Management System –

LMS), but the argument does not loose generality as the same issues are present on any learning platform, from Black Board, to ATutor, to WebCT, etc.

The syllabus used by E-LANE in digital alphabetization courses makes use of the ECDL/ICDL Curriculum [10]. The ECDL/ICDL (European Computer Drivers' License/International Computer Drivers License) curriculum it was originated in Europe. It aims to establish a minimal set of information technology skills that allow citizens to be part of the Information Society. This curriculum has minimal theoretical content, and therefore is very well suited to a learning by doing focus.

So how are we to integrate "learning by doing" (or Do It Yourself – DIY-) activities with the learning platform? Two options arise. Either dotLRN is modified so interactive simulations of the office software can be embedded or students will have to switch between the learning platform and the office tools they are supposed to learn. There are pros and cons of each as shown in the following table

<table>
<tr><td>Learning by doing - elements</td><td>Multitasking model:

• In dotLRN see, hear, read
• In Office program to DIY exercises following script</td><td>All in dotLRN model (split screen):
• In dotLRN see it - Do it
• step by step</td></tr>
<tr><td rowspan="5">See it happening animated screen shots

Hear it/read it explained voice over/ ppt or txt

Do It Yourself (DIY) follow exercise in the real program – open template file, do the tasks

Do It Yourself follow exercise in a simulated environment - practice the tasks</td><td colspan="2">cons</td></tr>
<tr><td>lack of feedback for achievement inside the program itself</td><td>Very small personalization of experience – have to follow strict script step by step. Greater cost of development</td></tr>
<tr><td colspan="2">pros</td></tr>
<tr><td>Very close to real life use of the program learned & to the ICDL certification

Learner is able to stop & start teaching material step by step following the script

Solutions of common problems can be organized in FAQ and posted in dotLRN</td><td>Can follow closely instructions

Cognitive load is diminished as student must not learn unrelated tasks</td></tr>
</table>

Table 3. Implementation Model

Since contents are so procedure oriented, it is evident that a great deal of quasi-mechanical tutoring will be needed, as opposed to theoretical lecturing, which should be minimal. Thus again there are several options for content delivery:

- Out of the dotLRN – tutor on place monitoring and supporting the process
- Imbedded in dotLRN
  - *Through frequently asked questions files (FAQ)*
  - *Screen shots sequences with DIY sections*
  - *Self-testing with correct answers available*
  - *Application sharing in small group exercises (2-3)*
  - *Use of platform to post finished exercises, to post questions and to encourage interaction in the groups of learners*

Also, monitoring, a teacher activity that is essential for feedback and tutoring, can be done asynchronously, which means that students turn their assignment at different times, or synchronously, which assumes that students turn their assignments at the same time

but not from the same place. Either case assumes that students work within the same time frame, and thus are susceptible to form teams and collaborate.

Nevertheless, a look at the eleven variables described above, shows that it is entirely possible to have instances of isolated learning. That is, a single individual that participant that follows E-LANE prescribed learning activities but that is not willing or even able to participate in group or team activities. In such cases, either platform or digital materials must be able to run in a stand-alone computer, for example as a auto-executable CD, and must heavily support self-assessment. Also, designers must make extraordinary efforts to develop materials that engage and motivate students and are self explanatory.

This all means that for E-LANE, platform and digital material are equally important, for in some situations where there is group support (by instructor or by synchronous or a synchronous group or team), digital material may not be as important as reliable platform support; while in other situations of isolated learning, digital materials become the core of the learning process, and the only support some students may experience.

Course Design Model

Different instructors, depending on the particular learning scenario, will always apply identical materials differently. Teachers will continuously vary activities to be carried out using the same material. Thus a framework to establish the relation between learning objects and activities becomes essential. This is done through the course design model. The main purpose of this model is to establish a framework for activity design and digital material interaction as well as interaction with non-digital resources.

While digital materials achieve visualization, navigation and interactions, activities that are carried out with those materials achieve motivation, long-term memory recall and proficiency. This is done by making learning useful. We will explain, but first we must answer the following question: how can we motivate learners to go the extra mile to learn new concepts and techniques? The answer is that you can't [19]. People must motivate themselves to be part of the learning process. This will be done only if they find the effort beneficial. Therefore learning materials should address clear and present needs of students as well as prepare them for the future. Likewise, learning becomes part of the learner's brain long term memory and endowed with recall mechanisms if learning contents can be related and associated to previous knowledge. This is called Meaningful or Significant Learning. Thus the most effective way to achieve motivation and long-term recall is by designing course activities that are based on student's background, interests, culture and environment. For example, how could we interest farmers to learn office tools? We could ask them use the word processor to keep records of soil preparation, planting and plant cropping. They could keep track of harvest and revenue information as well a construct manuals and guides. We could ask them to use a spread sheet to compute crop yield and expected revenue and to identify crops that maximize income. Finally, we could ask them to construct presentations geared to convince investors, bank officials and fellow farmers.

These activities are usually designed following some educational philosophy, such as Constructivism, Conductism or Cognitivism. Those philosophies derive in educational strategies, such as problem based learning, case based learning or project oriented learning. These techniques establish holistic approaches to learning, in which a goal is set forth to students in order for them to direct their learning in such a way that it is useful to achieve the goal Learning empowerment promotes good motivation as well as a sense of achievement. It also help to achieve meaningful learning by letting each student start from their own base of previous knowledge and letting them construct the rest from such a base.

Course Structure

A course is designed around ***Learning Units***, a top down design as it will be evident. Each unit is a set of activities supported by resources. Resources may be on-line materials (text, graphics, audio, animations, and video), off-line materials (books, articles and presentations), assignments, assessments, synchronous exchange (chat, whiteboard), forums, journal, surveys, voting, peer-review, etc. Those resources have activities associated with them. A Learning Unit is composed by four layers (an example is given further below) [20]:

1. **Material Database**: It contains digital materials such as lecture slides, images, video, animation clips, and so on. They are created by authoring tools and then saved into course storage.
2. **Primitive Content**: It organizes materials and **associated learning activities** to those materials in order to give it instructional meaning, application and management. In SCORM, this is called a **Learning Object**.
3. **Compound Content**: Combines primitive content to create a higher order activity set. This activity set requires planning, since the activities of primitive content that make up a compound content should be carried out in certain order. For example, to edit a simple text we see an animation, then try out a simulation, and then use a word processor to create a file and store it in student portfolio. Usually, although it may be possible to carry out the activities and review materials in different order, the order prescribed by the compound content is best.
4. **Learning-Flow Content**: Several pieces of compound content can be arranged to form a piece of learning-flow content. For example to create a newspaper article, one must discuss the general content of the article (or select from several choices), then design the general visual array, then type de text and paste the graphic, perhaps finishing with a journal entry and file storage in portfolio.
5. **Learning Unit**. Several Learning-Flow contents create a Learning Unit. Teachers would usually start course design and content authoring from this layer in order to have an overview of the learning contents and their links to learning-flow contents and other learning units.

From this hierarchy we can see that the order in which digital materials were developed or stored in the learning platform or digital media may become irrelevant, as a learning unit or a learning-flow content may require students to review digital materials (which

are directly related to learning gals) in different order from that established in the storage index. That digital material storage does not work like a book (and books some times may not be read linearly or completely). We can now clearly see, that the notion that a collection of digital materials, such a those found in Web Based Learning, is a e-learning course is, in fact, very wrong. All the pedagogical work is absent, and thus the effectiveness of such course is very limited.

Course characterization (implementation model) is very important for course design since many of the activities associated to primitive content require physical resources, like certain bandwidth for forum participation, multimedia viewing or interaction and communication among peers for group and team activities. Therefore, those activities should only be included if the required resources are present.

One of the extremes of course characterization corresponds to groups of people subscribed to a certain course simultaneously, which can attend meetings and have a supporting platform available with fully Internet connected computers. At the other end, we have an isolated learner, perhaps with a non-Internet connected computer, perhaps in a rural area, trying to bridge the digital divide, or a professional with a college degree trying to actualize her skills through e-learning.

In the first case, digital contents may not be as important as the design of group activities that, besides knowledge about the subject area, also provide soft skills and encourage certain behaviors. Activities thus, are the main focus of course design, and materials can be books, articles videos, etc., that can be shared by the group.

In the latter case, time may be of the essence, because usually, participants are motivated by needs such as getting a family supporting job, climbing the corporate ladder, having access to scholarships or grants, etc. Thus material development becomes paramount since students will prefer to shun collaborative and other time-consuming activities. Materials must engage students, and motivate them to follow on. Time spent in this type of learning can be reduced by reducing cognitive load, that is, the knowledge a learner must acquire which is not directly related to the subject area and which is necessary to reach the main academic objectives. Learners will want to have all activities integrated into one single environment and all resources should be readily available and easy to use. This is achieved by thorough use of interactive materials and on-line simulations that do not require students to disengage the e-learning software in order to practice. In our case, a self-paced individual course should contain Flash or Java simulations in order to practice skills, for example, erasing files or editing text embedded in HTML pages for module 2 of the ICDL curriculum. In contrast, in a group environment, students would rather be encouraged to use the real operating system and word processor and to discuss their results while forming a portfolio.

In this second case, instead of using discussion groups, interaction with materials would be enhanced by activities that require students to elaborate different kinds of diagrams, essays and presentations, or if possible, through interaction with the instructor. And

again, when possible, all these activities, if not too time consuming, should be done inside one single environment.

Courses such as ICDL curricula, where the target learner is the individual learner, can be self-paced (e.g. one learner interacting with the instruction) or a small group of learners interacting each individually with the instruction under instructor supervision.

Conclusion

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