Issues of importance in engineering education and distance learning

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ABSTRACT: In this article, the author examines some of the basic principles and tools that may serve in engineering education, in conjunction with professional development aims, in a distance collaborative setting. These principles take into consideration basic learning theories, collaborative learning, adult learning and educational methodologies. A natural consequence of the increasing globalisation of industry, science and education is increased intercultural communication. Engineers work in industry, science, education, as well as government and non-government organisations. Therefore, it is important for engineers to get the opportunity to acquire a basic understanding of the principles of global negotiation. This knowledge, particularly when combined with practical experience, will allow the globally interacting engineer to develop effective negotiation skills.

INTRODUCTION

It is commonly agreed that there is nowadays pressure on higher education to provide educational opportunities to larger student populations. On the other hand, the insertion of new technologies in education presents challenges for the adoption of new educational methodologies. In parallel to this, new pedagogical strategies are being investigated in order to expand the study material from discrete cognitive areas to interdisciplinary approaches and improve professional skills, aiming at the smooth transition of students from academic to professional activity.

Engineering education, among other disciplines, takes place mainly through lectures. However, the emotional and cognitive results of this teaching method are being under reconsideration [1]. As far as environmental education is concerned, apart from the cognitive component, the educational environment should also provide opportunities for the additional development of the following aspects, as identified by Georgopoulos and Tsaliki:

- Holistic approach to environmental problems: Regarding humans as environmental elements, not only technological solutions must be considered, but also historical, political, economic and cultural parameters;
- Interdisciplinary approaches to problems: The complexity of the environmental issues, combined with specialised curricula of higher education, requires interdisciplinary approaches;
- Environmental sensitivity, positive attitudes, beliefs and action are necessary to facilitate a sustained structure for social development;
- Experiential learning opportunities with field studies are required so that the real conditions that formulate the functioning framework of the planned work can be more readily understood;

- Problem-solving, communication, research, observation and decision-making skills need to be improved;
- Intercultural approach to problems: cultural data needs to be realised and respected, as it can reveal new aspects of environmental problems and define special approaches during decision making, especially at the social level [2].

Therefore, it is clear that engineering education should target equally the whole personal improvement status (cognitive, emotional and moral). So critical thinking, decision making, analytical and compound thinking and creativity skills, along with realistic social and economical parameters, safety rules and aesthetics, constitute dimensions of the new educational approach [3]. Interdisciplinary approaches to engineering problems often lead to the interdisciplinary planning of environmental protection works in real life. A collaborative environment at the educational level mirrors reality and provides the framework for necessary skills improvement.

New technologies may support educational procedures in a wider framework than traditional types. New possibilities arise that contribute to the implementation of open education systems that recognise students' right to define their own pace, time and place of study. Distance learning is a methodology that implements a more flexible approach to the educational procedure than traditional lectures. It may, therefore, provide solutions that can satisfy environmental education needs. The adaptation of a distance collaborative environment that serves environmental educational is an educational aim itself.

On the other hand, the increasing globalisation of industry, science and education is a clear fact. Negotiation has generally been viewed as a subject of those social relationships concerned with the resolution of conflict [4][5]. Negotiation has been described as a give-and-take process and a problem solving process. The topic of negotiation has originally been the domain of psychology and related disciplines, but has

become increasingly interdisciplinary with the migration of concepts and learning across disciplines [4][6]. With the emergence of a globalised world, researchers have started to investigate the effects of culture on the negotiation process and integrated the cultural dimension into the negotiation domain.

EDUCATIONAL CONSIDERATIONS

Learning Theories

Human beings learn by interacting with their environment. During the previous century, diverse factors that contributed to learning differentiated learning theories. Some of them supported the idea that learning factors are presented to the person by the environment, which in turn is stimulated and responds in a certain manner.

Other psychologists advocated that learning factors are within the person, who creates his/her own models of the world. Those models function at parallel levels, thus gaining speed and time for all the needed calculations. Educational aims should focus on the models' reshaping in order to assimilate scientific discourse.

Constructivism has been connected with Piaget. He introduced the successive developmental stages that are connected to biological development. Elements from each stage are included and expanded to the next one after a reconstruction of the cognitive functions caused by interaction with the environment. Therefore, in the educational setting, the student must face a cognitive contradiction that may cause learning.

Vygotsky supported the idea that intellectual development is not only based on the person's efforts, but is also influenced by the cultural environment that the person lives in. He expanded Piaget's perspective by introducing the Zone of Proximal Development (ZPD). He introduced the concept of social constructivism whereby each person can achieve more than the level he/she is presumed to be through proper guidance from his/her immediate environment. As help is reduced, the person can then conquer next level.

Collaborative Learning

Learning theories initially differentiated the social and psychological aspects of learning. Gradually, newer theories have combined elements from both of these areas.

The learning situation becomes more interesting and challenging when conducted in a collaborative setting. Collaborative learning is a situation in which at least two persons learn – or at least try to learn – something in common. Collaboration brings out different opinions and generates cognitive contradictions that may subsequently facilitate the learning process. Collaborative setting is a unique scheme in time and space that constitutes Vygotsky's social environment and provides opportunities for learning to occur. However, it is important to realise the cognitive system to be focused on in a collaborative learning analysis.

Dillenbourg et al define three different approaches to collaborative learning on an axis [7]. At the edges of the axis lies the theory of Socio-Constructivism (SC) and the Distributed Cognition (DC), respectively, and, in the middle, Socio-Cultural Learning Theory (SCLT). In the SC approach, which is based on Piaget's theory, each student's personal intellectual development within the team is considered. The SCLT approach expresses Vygotsky's view, whereas the DC approach regards collaboration as a procedure of knowledge creation and preservation within the team. In this case, the team itself is the cognitive system to be studied.

Metacognition

Flavell considered thought as a flow to and from a system of mental models, which compose human memory. What is in question is the method of saving and retrieving information from memory and structural changes in memory while growing, and how to control these procedures. In 1979, he introduced the term *metacognition* [8]. Newer research shaped a more complete definition of metacognition, which includes:

- The knowledge that a person has about his/her knowledge of certain actions that he/she has to take and of his/her cognitive and emotional situation;
- His/her ability to monitor and adjust consciously his/her knowledge, actions, as well as his/her cognitive and emotional situation.

Metacognition is, therefore, a coordinating level that positively influences academic efficiency as many studies have shown. According to Livingston, lectures are not sufficient for metacognitive strategies to be implemented by the student [9]. Metacognition is highly connected to experience and continuous efforts from the student who sequentially:

- Plans his/her actions during the teaming procedure;
- Defines the learning task and makes predictions on the difficulties;
- Monitors and adjusts the learning process defining what he/she does and does not know, tunes his/her intentions and working speed;
- Evaluates his/her learning process.

An acquaintance with metacognitive strategies helps generalisation and knowledge transfer to at least near-cognitive areas, which is a crucial issue for engineering education. Although metacognition is a personal procedure, its implementation skills can be taught within an educational environment. Moreover, considering a collaborative scheme, metacognition may be adopted either by each student or a whole team. Research shows that teams that adopt metacognitive strategies generally managed better [10].

Adult Learning

Despite the differences among the most influential learning theories, there are some common views: people learn as they interact with the environment. Each person constructs his/her own mental models to realise the world; thus, a person learns with his/her own special and conscious means. People learn better when they are involved in experiences and adopt metacognition processes. Although these refer to all people, adults have some special characteristics. Jarvis presents the theories of five important theorists of adult learning, which converge to the crucial role of experiential learning [11]. Adults learn even better when the experience is connected to their interests.

According to Race, an educational procedure that is addressed to adults must provide key phases that constitute the adult learning cycle [10]. These phases are as follows:

- *Wanting*: The person is prepared to engage in an educational experience;
- *Acting*: The person is involved in the action and enriches his/her experiences;
- *Feedback*: Through observation and the elaboration of new experiences, the person extracts conclusions and assesses these himself/herself;
- *Digesting*: The person combines his/her experiences to the relevant theoretical background. Utilising metacognition, he/she makes generalisations and plans his/her next actions.

The educational environment must provide the possibility for all phases of the learning cycle to be implemented. This will be achieved after a proper educational design that addresses students' needs.

COLLABORATION SUBJECT

In designing the distance collaborative setting, special care should be given to the establishment of collaboration, ie working on the same subject and with common aims, and not coordination (working in parallel and synthesising the results).

The subject to be collaborated on depends upon the educational methodology to be used. A problem that can be solved analytically is a usual choice in the traditional classroom setting. However, distance imposes difficulties and student motivation has to be kept alive. The case study methodology introduces many useful dimensions to the settings under consideration.

A case study is an excerpt from a real fact and so it carries its characteristics. It is a semi-structured problem, similar to those that engineering students will face in their professional life. It is an *open-ended* problem to which there is more than one solution that can be reached analytically. The common aim for the students involved is to engage in dialogue, and converge on a solution that reflects their common aspects on the problem. The case study method serves distance collaboration within environmental education, as it facilitates the following:

- Challenges the adaptation of a rich dialogue, thus providing the conditions for students' practice in transferring speech into written forms;
- Connects academic life to reality, having simultaneously more possibilities to be close to students' interests. In this way, it offers a strong motivation for students to be involved in the collaborative procedure, according to adult learning theory;
- Incorporates team learning (the DC approach) as the emphasis is on the collaborative procedure and not on the final delivery itself. It is a field for personal learning (the SC approach) as each student's knowledge and beliefs are challenged through collaboration;
- Projects the human dimension, as it may reveal inefficient choices during planning, poor workmanship or even social contests. In this fashion, unsuccessful solutions are critically examined and socio-technical contrasts reveal the necessity of risk management and general decision-making processes concerning environmental issues.

The case study method was introduced and utilised in traditional classrooms. Transferring this methodology in a distance collaborative setting requires other students' preparation for distance communication.

CULTURAL NEGOTIATION SKILLS

In domestic negotiations, both negotiators have the same cultural background. As a consequence, the negotiators make reasonable cultural assumptions and fairly accurate attributions. However, in intercultural negotiations, negotiators cannot take common knowledge and practices for granted. Culture has a general impact upon the two parties interacting, thereby also indirectly influencing the negotiation process. Martin el al state that culture impacts negotiation in the following four processes:

- Conditioning one's perception of reality;
- Blocking out information inconsistent or unfamiliar with culturally grounded assumptions;
- Projecting meaning onto the other party's words and actions;
- Impelling the ethnocentric observer to an incorrect attribution of motives [12].

Culture affects the range of strategies that negotiators develop, as well as the many methods whereby they are tactically implemented. Culture directly impacts negotiations through the actors and manifests itself at four different levels, namely:

- The cognitive level, relating to ways of perceiving the nature of the game that negotiators are playing and what is at stake;
- The level of beliefs in that culture provides a set of values that operate as goals, thereby orienting the behaviour of the negotiators;
- The range of acceptable behaviours that culture allows or emphasises as a most appropriate response to the move of a counterpart;
- Identity, which concerns the degree of consciousness that an actor has developed and how sensitive he/she is about being challenged.

COMMUNICATION ELEMENTS

Communicating at a distance can be realised via different means, depending on the synchronous or asynchronous model of collaboration that is chosen. In general, the first one leads to more expensive and technically demanding solutions, whereas the second one is easily implemented and serves student's needs (regarding pace, time and place of study). In a written asynchronous collaboration model, students transmit and receive messages. Due to the lack of body language signals, they have to express themselves with the best clarity and completeness that they can.

The role of questions in a collaborative setting is very important as they encourage communication, reinforce cognitive curiosity, improve thinking, contribute to a lack of knowledge realisation, serve as a means of experiences and knowledge exchange, and facilitate the expression of thoughts and feelings.

The realisation of questions can contribute to a student's collaborative skills improvement. Questioning is a means to challenge the mental functioning of the receiver. The mental effort made by the student when answering a question depends on the question's phrasing. Questions are organised according to Bloom's classification as low level questions (recall, understand, implement) and high level questions (analysis, synthesis, evaluation) with less or more difficulty, respectively.

EDUCATIONAL TECHNOLOGY

There are diverging technological means that facilitate distance learning since its appearance about 150 years ago, from surface mail to satellite transmissions. However, the computer's development, along with the expansion of the Internet, constitute easy methods to implement distance education programmes. According to Mason, Internet-based educational programmes can be classified as follows:

- *The integrated model*: collaboration and educational targets are of greater importance than the published material on the Internet;
- *The content + support model*: the educational material is downloaded from the Internet, but face-to-face consulting from the supervisor is also used to support students' efforts. The quality of the material is of great importance in the structure of this model;
- *The wrap-around model*: similar to the previous one, this model utilises material published on the Internet, but employs more collaborative activities [13].

By reviewing some well-known Virtual Learning Environments (VLEs) that employ Internet technology and by adopting criteria of interest, one can come to realise the following aspects:

- In a collaborative setting, the communication model often employs semi-structured interfaces through which students collaborate in a predefined way. This approach is used when gathering specific data of interest (eg *CLARE*, *CSSLE*, *the Collaborator Work*, *Web-SMILE*, *Belvedere*, *Convince Me*, *Coordinator*);
- There are pedagogical neutral environments that provide the teacher with a set of tools for organising the lesson (eg *WebCT*). These tools usually belong to the first and second type of Mason's classification;
- Most programs (eg *Asymetrix Toolbook*, *Blackboard*, *eCollege*) that assess students are focused on the content of the collaboration and not on the collaborative activity itself (eg the *DEGREE* project). Feedback on collaborative activity is usually based on presentations of results after statistical analysis. In some programs, the student access profile is generated, including information regarding his/her initial date of access, number of times accessed, hours spent on a particular topic, etc. Using statistical analysis (eg in *Asymetrix Toolbook*, *Blackboard*, *Generation 21*), the user can see his/her statistical results regarding the correlation of access with the whole spectrum of lesson topics, or histograms (*WebCT*) or outputs for further process from specialised statistical packages (eg in *Learning Manager*, *Ucompass*);
- In most cases, students collaborate on the analytical solution of a problem, whereas the case study methodology is hardly used, mainly due to assessment difficulties;
- Metacognitive thoughts are indirectly produced either from the comments on a student's work by his/her colleagues (eg in *First Class*) or from self-evaluation forms (eg *Blackboard*). Pre-educational and post-educational tests are applied in *Eloquent* in order to evaluate the degree of cognition of the active student. Some instructions for the development of learning strategies or concept maps are included in *Blackboard*, *Virtual-U* and *Team Wave*;
- In some cases (eg *IntraLearn*, *WebCT*, *Ucompass*, *Web Course in a Box*), students can create their own Web page and/or portfolio as a motivation for their active participation in the educational process;

- The teacher's role is either obvious, as he/she may intervene or even participate in the teamwork or be substituted by system supporting models. In the latter case, many Artificial Intelligence (AI) methodologies are employed, including agents, expert systems, fuzzy logic, Baycsian networks, etc.

CONCLUSIONS

Engineering education may be enhanced by the use of new technologies. Distance learning as an educational methodology may serve environmental education needs. However, designing an educational tool that serves its purposes constitutes a challenge, as interdisciplinary dimensions have to be taken into account. Basic principles that should be kept in mind in designing a tool for distance environmental education are highlighted here; these mostly refer to a definition of a clear pedagogical aim within the environmental education philosophy, the enhancement of communication model to promote critical thinking, collaborative skills improvement through proper methodological choices and technical means support, and the inclusion of a strong collaborative dimension. On the other hand, regional culture influences the demands in negotiation. Much of the negotiation also depends on personal predispositions and individual character traits. Engineers are often involved in cultural negotiations in order to solve crucial problems and engineering students must be given access to quality education and training that will make them better negotiators.

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