Modern Techniques and Alternatives for Generative Learning Applied in Engineering Education

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Abstract –**The unprecedented, aggressive institutional competition and quickly changing students instructional expectations make it clear that we are assisting to a new phase in higher education. The engineering domains must fulfill specific needs for developing intuitive and easy-to-use teaching and learning instruments. In this paper, the authors outline the necessity to engage the students into an interactive learning process, generative of knowledge. Course-management tools and efficient instruments allowing to the teachers to build online course material, adjusted to specific and local students' needs, appear as necessary in assisting of this objective.**

Keywords: generative learning, engineering education, professional skills, communication abilities

I. INTRODUCTION

The today's challenges faced by universities all over the world are well documented. For all range of disciplines in various branches of engineering the efficient techniques are emphasized to develop the students' ability to use interdisciplinary knowledge and skills for understanding and solve engineering problems. The desired objective is to teach students to recognize the problems, to develop original instruments for their solving, followed by continuous generative knowledge in a specialty field.

In the actual learning context ensured by the engineering education system is more and more important to find the correct answer to the following question: *Is the purpose of the academic system to simply supply information stimulating only memorization or achieving single solutions or to stimulate and help the students to discover the problems' solution by research and testing?*

Regarding this aspect, there are arguments showing that the actual educational system should achieve a balance between memorizing basic information helping to supply necessary components of the cognitive process and the true knowledge achieved by study of theory, empirical and practical research, experience, collaborative contribution of classmates and interaction with instructor.

Our institution initiated even two years ago a study that tries to detect the students' reaction to the efficacy and attractiveness of some types of traditional or asynchronous instructional tools used at varying level studies, as well as their needs for synchronous modern tools.

More than that, by trying to find the best institutional instruments to organize a qualitative distance education system, the disadvantage of the fact the learning activities cannot always be collaborative should be overcome. The instruments and methods that stimulate the interactions among learners are required not only to simply generate rich problem solution, but also to train the students to solve the real-world problems, in the same manner as is requested by the employers in the actual working places.

For sure, implementing a quality learning system requires a full, not only declarative, institutional commitment. The present study didn't aimed to investigate all the quality elements of institution education system, but it focused on student satisfaction, without omitting interrelation with faculty satisfaction factor, the cost or learning effectiveness, or even the participants' access.

II. TEACHING METHODS AND INSTRUMENTS FOR GUIDING OF GENERATIVE LEARNING

The local industry seems to meet a strong development. The requests of employers are more and more elaborated, asking not only for good professional skills, but also for communication abilities and collaborative capacities. Therefore, the actual learning instruments and techniques must stimulate the students to organize their instructional activity on the team-principle, like the employees of a company.

A balanced educational system must contain sections for allowing to the student to reach the problems' solutions individually by theory study, research or opinion paper research, as well as by collaboration with his/her community participants, taking the advantage of the collective knowledge, interpretation, experience and contributions of classmates.

In Fig.1, the structure of such a balanced educational system is presented, relied on generative pedagogy

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and able to combine all these elements concurring to a high performance student training.
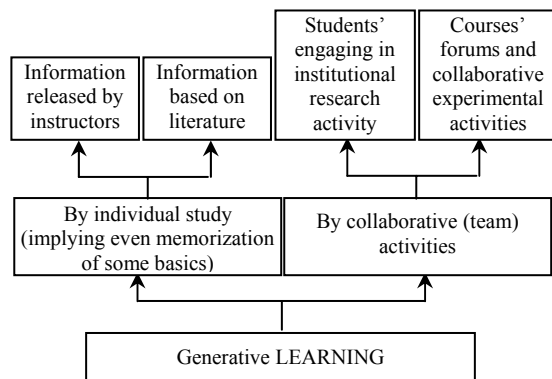

Fig. 1. Principle structure of a balanced educational system

At Faculty of Electrical Engineering - FEE (University of Craiova) some research studies were performed in order to highlight the impact of the non-interactive or interactive learning techniques or of the asynchronous or synchronous communication tools on the education quality. These studies intended to survey the communication tools chosen by the students for different activities of learning and institutional training, as well as their opinion regarding the efficiency of the instructional tools used by today's institution structure for different course levels.

III. LEARNING AND TEACHING TOOLS AND METHODS

The central question on that the present study was focused is: *Which kind of the pedagogical methods should be the most appropriate for students in order to stimulate them in developing of high-order thinking skills based on gradual information achieving, followed by a generative and further, by a constructivist learning way? Do these methods help the further employees to reach those high competencies requested by the actual labor market?*
If the answer is YES, *which are the most efficient and appropriate tools for implementing these methods?*
By the authors' opinion, an efficient student training process must start with the real working-environment problems that they should solve. The students should be trained to find these problems' solutions not only by theoretical studies, but also by empirical researches, experimental work and paper releasing of personal conclusions. Of high importance is to find the best alternatives of academic communication mode, for all the alternative instructional dialogue pairs: teacher-to-student, student-to-teacher, or even student-to-student. These alternatives must be able to respond to the students' idea about the advanced education and expressing creativity, without affecting the institutional goal of keeping a high quality level of the taught information.
So that, there is a need to make no distinction between learning activities and communication, by creating

interactions among learners, in the same idea, with the instructor. Therefore, there must be defined a conceptual framework to support communication tools for the students, adjusted even to particular educational situations specific to our institution, FEE. At FEE these tools are not yet wide-scale integrated in online educational platforms. On the other side, this integration is not necessary even now, but at least partly, in the next future. Even so, they know a development based of the forum models, perfectly adjustable even to the next curricula of graduate-level learning at a distance. The main features of these tools are:
- A good collaboration among and between small working groups;
- Effectiveness in transmitting of complex ideas and information;
- Attractiveness for the students.
At the national level, the engineering institutions try to use various pedagogical approaches for various graduate levels, which include:
- The traditional pedagogy of instruction, which is curriculum focused, and is developed by a centralized educating group or a single teacher;
- Pedagogies having a social-constructivist feature based on the use of discussion forums, blogs, wiki and on-line collaborative activities.
- Some other contextual pedagogical approaches, focused on the environmental and social aspects, which can stimulate learning. These ones are used as usual practices for the student practical stages in local companies or abroad.
Unfortunately, there are (still) only few pedagogical attempts that stimulate the cognitive perspective of the learning process or that of behavioral nature, focused on the skills and behavioral outcomes of the learning process. The emotional perspective of the learning process focused on its emotional aspects as motivation, engagement, or even fun, seems quite inappropriate for the most technical academic strategies, even they should be the most and fast adjusted to the expectations of a eager-of-technology category of students.
For sure, the today's technical universities are seeking for collaborative approach that opens educational content creation to a wider group including the students themselves [1, 2].
Therefore, the increasingly robust technical infrastructures and user-friendly learning environments become promoters of e-Learning. Among the technologies used in e-Learning can be mentioned: multimedia CD-ROMs, simulations, e-mail, web-based teaching materials, Educational Management Systems (EMS), Learning Management Systems (LMS), blogs, collaborative software, web systems, hypermedia in general, etc.
By taking advantage of the variety of course-management and customization tools, the teaching staff of FEE recently started to implement online solutions for the students. So that, 8% of the undergraduate disciplines and 15% of the Master

courses are customized using one of the free open source Web-based Learning Content Management Systems, ATutor [3, 4] (see Fig.2).

The objectives of the courses and the tasks of educational process can be efficiently accomplished using this tool due facilities as:
- Adding and modifying removing course materials;
- Creating online homework and tests;
- Creating specialized exercises, setting test options;
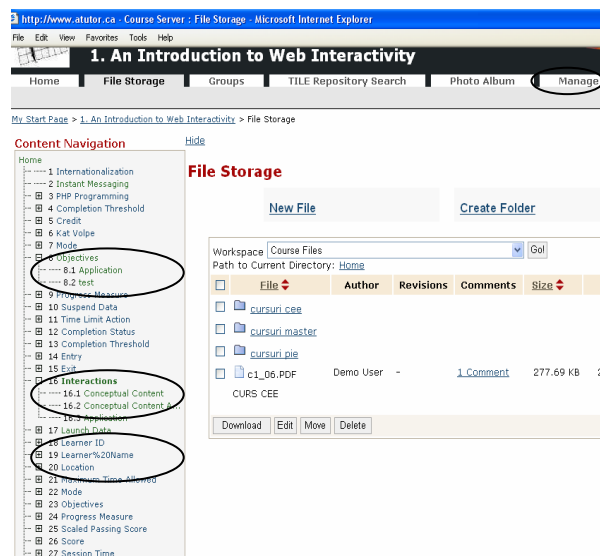- Managing grades;
- Course sharing and managing course groups.

Fig. 2. Screen shot of an ATutor course

Some other LMS free sources could be used, according to the instruction necessities, and so that there can be mentioned: Claroline, Dokeos, eFront, ILIAS, Moodle, OLAT, etc. At FEE, there is going to be implemented a high performance project by purchasing of Angel LMS.

Also, one of the most appealed instruments used in FEE's student activity is the computer-based training service. This one allows to the students to execute special training programs on a computer relating to their specialization. Computer-based training program can be integrated with the applications, so that students can practice using the application as they learn, being a viable option for group and individual instruction [5]. The digital educational resources of FEE's departments are completed with numerous education softwares. Parts of them are purchased as performant applications, being in generally interactive packages for simulation and analysis aspects studied at different specialisation disciplines. There is worth to be mentioned that an important part of the computer-based applications were developed during the research activity of complex teams formed of master and doctoral students.

The Web-based training is another type of training used by various disciplines tutors at FEE. Web-based training includes interactive methods, especially bulletin boards, chat rooms or instant messaging, the next step being some trials of videoconferencing.

For the moment, the FEE academic team didn't usually experiment the online testing systems, but only quite traditional evaluation at specific times.

The most of international reports are not decisively concluded about the satisfaction level of the students with their on-line classes vs. the traditional ones, but for sure, all of them are aware of the need of an efficent communication asked by the interaction level between class-participants, as well as by the need for a collaborative tasks' organisation [6, 7]. Nevertheless, the FEE's initiative to determine the students' preferences for one or the other of the systems is quite appropriate in the context of the institutional changes imposed by the Bologna convention adjusting.

IV. RESEARCH STUDY DESCRIPTION

At Faculty of Electrical Engineering, University of Craiova (FEE) a small investigation team was formed one years ago in order to identify and evaluate the modern tools and methods of teaching and learning.

The team was consisted of two teacher coordinators (lectors of Professional Communication course) and students interested in enrolling in this study.

Notably, some of the students involved in this study are employees working in the Faculty's research department. The others are attending undergraduate courses of FEE (semester III to IX) as well as the Master studies (semester I to IV). The students' teams were also completed with 4 of those involved in University's PhD programs.

A significant part of this investigation was to define the role/features of different teaching/learning tools and environments. Particularly, the research team was interested in finding the answer at different students' preferences for one or another of pedagogical approaches or structure of educational materials [6].

The communication tools chosen for solving of a stated problem was another main direction followed by the study. The study outlined that for solving of the same problem, the students choose three different means. During the present study, the evaluation of this objective supposed the analyzing of the behavior of small group of students (3 to 4) in three case situations:
- Solving of more or less complex problems, during application classes;
- Developing of virtual case studies, by association with solution proposals during semester project activity;
- Launching of real study cases and developing of some solving solutions during diploma, master and PhD paper activity.

The purpose of the research team was to define the most appropriate method to stimulate the collaboration among the students, which is perfectly adjusted to the local specific and conditions, is applied with instruments freely chosen by the students and offers the right strategy for obtaining the problem solution.

The study supposed questionnaires, interviews and regular observations made up during two semesters for getting a feedback from a number of 165 students: 2,4 % researchers, 9% master students, and the others, undergraduate students. There where only 86,3 % of questionnaires suitable for results' analyzing.

The original survey questionnaire included 30 questions with multiple-choice answers and spaces to include comments. Some of them are given in Table 1, here being presented only the main study directions followed by the extended questionnaire.

After two weeks since the survey initiation, a set of questionnaires was analyzed and some questions, ambiguous for the students or offering incomplete information, were reformulated.

Table 1. Content of study questionnaire

Question to the students	Linear scale (if the case)			
	1	2	3	4
1. Role of education in your personal development a. helps to develop my knowledge and instruction abilities in generally b. helps to develop the knowledge in a field of high interest for me c. more chances in professional career d. self-esteem increase	-	-	-	-
2. Previous instruction type: a. technical studies; b. others	-	-	-	-
3. Time spent for individual instruction during semester/before examination a. less than 3 hours/dy b. within 5 hours/dy c. more	-	-	-	-
4. Origin of references used in your professional instruction: a. instructor materials; b. institution library; c. e-library; d. domain magazines; e. Internet	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐
5. Efficiency rate of information receiving for different instructional methods: a. traditional classroom lecture b. interactive computer-based training programs c. web-based educational programs	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
6. Attractiveness rate of information receiving for different instructional methods: a. traditional classroom lectures b. interactive computer-based training programs c. web-based educational programs d. combination between a and c	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
7. What weight do you think should have the e-Learning tools in your professional education?	☐	☐	☐	☐
8. Efficacy of different procedures used in achieving and applying of information: a. method exposed step by step by the instructor b. individual procedure, with collective results presentation and ambiguous notion clarification c. procedure established in the framework of an working-group d. others	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
9. Level of independency allowed by instructor for modality of a given problem solving: - method - tools - team/individual working	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
10. Level of independency assumed by you in solving of a given problem	☐	☐	☐	☐
11. Role of communication in a student working-group: a. for establishing of a general strategy in solving the given problem b. for solving completely the given problem b. limited to clarifying of some aspects solved individually	-	-	-	-
12. Interactivity level with the instructor for solving of a given problem: a. permanent b. occasional c. imposed	-	-	-	-

	Linear scale (if the case)			
13. Attractiveness of communication modalities for collaborative tasks: a. phone b. e-mail c. programmed meetings d. chat/mess e. forum	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐
14. Efficiency rate of communication modalities for collaborative tasks: a. phone b. e-mail c. programmed meetings d. chat/mess e. web-forum	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐

IV.   RESEARCH RESULTS

Many of the inquiries involved procedural or mechanisms type of questions, having simultaneous multiple answers.

The study's questionnaire tried firstly to establishe the former educational profile of the students and the role of education in their personal development. The majority (2.*a. - 95%*) was previously involved in technical and informatics education field, the present study cicle coming as a continuation of their instruction. Therefore, as a natural consequence appears the fact that most of the students look at the study cycle they presently attend as a mean enhancing their proffesional chances (1.a. - 40%; b. – 46%; *c. - 58%*; d. – 13%). Their individual instructional program is in the most of the cases less than 4 hours/day as a media during the whole semester, which is not quite satisfactory since the exams' sessions are considered, too (3.a. – 16%; *b. – 55%*; c. – 29%). Totally unsatisfactory is the tendency of choosing as references especially the class teachear materials or information on the simple Web-sites, being almost neglected the speciality books, magazines or e-lybray items (4.a.- 91%; b.- 28%; c. – 21%; d. – 21%; e.-91%). This situation indicates either the lack of education in completing the achieved information, or, in some cases, missing of the alternatives. So that, the observation following the next question is not at all surprising, but it gives some hopes regarding the personal initiative of the students' activity. Most of the students consider computer-based class activity as a quite efficient method for a good information achieving (5. a.- 28%; *b. – 66%*; c.- 6%). For the present, they not see a completely web-based learning system as an alternative for their education, even they consider this educational system as attractive enough (21%) from many considerents (6. a.- 12%; *b. 54%; c. – 21%*; d. – 13%). Consequently, the opinions about the importance of e-Learning tools in the students' instruction are quite divided. A part of the students exclude these tools as alternative (39%), while another important number of students considers these tools as some interesting ones (30%). This last category make part of last-semester undergraduated students and master students that were more accustomed with e-Learning tools developed at FEE disciplines.

Speaking about the different procedures used in achieving and applying of information for solving a given problem, more than a half of the students cosider the method exposed step by step by the instructor that having the best efficacy (8.*a.- 53%;* b.- 15%; c. – 16%; d. – 16%). The reaction proves an inertial learning attitude imposed by the former educational methods, which didn't stimulate creativity's expressing.

Regarding the independency allowed by instructor for modality of a given problem solving, the students consider their options relatively restricted (question 9, on a 1-4 linear scale: the attribute value of the method alowed is mostely 2, as well as for the team organisation; the attribute value of the tools allowed to be used is in their opinion higher, equally to 3). Even so, almost 39% of the study involved students assumed themselves a 3-grade independency for method and tools and a 4-grade for team-organising (question no.10).

If the students should solve a given problem, they consider as very important the role of communication in a student working-group, especially for establishing of a general strategy reaching the task, and not necessarily for achieving the final solution (*11. a. – 55%*; b. –13%; c. – 32%).

A half of the students consider the interactivity with the instructor for solving of a given problem as occasional, but there is a considerable percentage, which considered the permanence of this interactivity as natural (12. *a. – 45%; b. – 50 %*; c. – 32%).

The last, but not least, the attractiveness and efficiency of communication modalities for collaborative tasks were evaluated. The phone, e-mail, programmed meetings, chat/mess, web-forum were their known alternatives. The results were (on a 1-4 linear scale):

-      question no.13 (attractiveness):
a: 1-27%; 2-21%; 3-16%; 4-36%
b: 1-11%; 2-27%; 3-29%; 4-33%
c: 1-23%; 2-23%; 3-31%; 4-23%
d: 1-67%; 2-13%; 3-13%; 4-7%
e: 1-17%; 2-10%; 3-25%; 4-47%

-      question no.14 (efficiency):
a: 1-12%; 2-14%; 3-13%; 4-31%
b: 1-18%; 2-18%; 3-28%; 4-35%
c: 1-43%; 2-31%; 3-11%; 4-15%
d: 1-77%; 2- 9%; 3- 8%; 4- 6%
e: 1-18%; 2-21%; 3-24%: 4-36%

Consequently, it can be stated that the web-forum communication is the best communication option for solving a given problem, even the e-mail and programmed meeting are still a viable alternatives. The study participants motivated it due to the fact the opinions can be exposed in an easily accessible

framework of the problem's topic. Different interaction's types are possible, taking advantage also by the instructor's support, after a proper justification of the problem aspects. At the opposite side, there is the chat/mess communication, considered no longer a viable alternative for professional task due to relatively low information's structuring.

Not even the programmed meetings consist a choice for the instructory meetings, the reason being given by the time restrictions closed to deadlines.

V. CONCLUSIONS

Previous observations justify the need of a new approach in using of new learning/teaching instruments particularly at Faculty of Electrical Engineering (University of Craiova). The observation can be extended even for the most of technical academic institutions.

Pedagogical elements defining the new methods and tools should include new or only properly adjusted structures or units of educational materials. These could be a lesson, an assignment, a multiple choice question, a discussion group or a case study, or all these together, with independent format.

For starting development of e-Learning contents at Faculty of Electrical Engineering, the pedagogical approaches need to be evaluated. Simple pedagogical approaches make it easy to create content, but lack of flexibility, richness and downstream functionality.

On the other hand, complex pedagogical approaches can be difficult to set up and slow to develop, though they have the potential to provide more engaging learning experiences for students.

Somewhere between these extremes there is an ideal pedagogy that allows a particular educator to effectively create educational materials while it simultaneously provides the most engaging educational experiences for students. Course management tools allowing to the teacher to build material online, in combination with traditional lectures with class interaction seem to be the most suitable communication alternative for technical academic education. This alternative not only ensures that the information suppliers (instructors) to be as more implicated in the communication process as the receivers (students). In the same time, the students' options for new, for originality, for expressing themselves or simplicity desire can avoid to get in some eventual conflicts with their traditional education style, as it can be concluded from the present conducted study.

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