New Perspectives in Engineering Teaching

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Abstract — Recently, the ever increasing number of students in engineering degrees has raised new concerns about teaching and effectiveness quality to both society and government. To overcome these new difficulties the Polytechnic University of Valencia has started several pedagogical initiatives including training programs for novel teachers. It is commonly accepted that teaching in engineering degrees requires specific training. From this perspective, the Polytechnic University of Valencia in its Fifth Edition of the Initial Pedagogic Training Program (FIPPU) has gathered a group of novel teachers coming from different Technical Schools, Departments and backgrounds. The final objective of this project is (a) to share academic experiences, (b) to enhance the teacher’s own perspective based on mutual interdisciplinary learning, (c) to carefully consider the diverse teaching methods and the methodological innovations used. We aim at knowing which methodological strategies are more suitable while teaching at engineering degrees; which procedures and/or resources are appropriate and which ones should be disregarded. Finally, we also want to learn how to increase student involvement, independent self-directed work and critical initiatives from our students. Usually engineering teachers tend to share experiences with fellow teachers from the same department or field. The FIPPU Project, however, encourages the exchange of academic experiences at higher levels allowing the discovery of new teaching methods that otherwise would be very difficult to know. As a conclusion, we propose to share our different experiences in this program as well as results and future perspectives.

Index Terms — Cooperative learning, educational methods, “learn to learn”, multidisciplinary learning/teaching, teaching training.

ACTUAL AND FUTURE STATE OF OUR TEACHING

In the general framework of the European Union, which initiated its activities with an economic view only, there has been a clear trend for convergence in different areas. These areas include important aspects as juridical, social and educational among others. In the educational area there has been an ongoing effort driven to develop the European Space for Higher Education which will allow for an easier validation of the different university degrees, as well as for an optimum training of the students and their integration in a borderless and unified labour market [1].

In the European Union a new dimension is started with the declarations of Sorbonne (1998) [2], Bologna (1999) [3] and Prague (2001) [4]. The principal objectives included in the Bologna Declaration that are further confirmed in Prague, constitute the base and the compromise for the establishment of the European Space for Higher Education before 2010, which briefly states:

• Adoption of an easy and comparable system of diplomas. Implantation of the Diploma Supplement.
• Adoption of a system essentially based on two main cycles: undergraduate and postgraduate.
• Establishment of a credit system (ECTS) as the most suitable way of promoting student mobility.
• Surmounting the different hindrances that prevent the free circulation both of students and lecturers.
• Promotion of European cooperation in guarantee assurance
• Promotion of the necessary European dimension in higher education.

Europe and its universities face today a social and cultural change. In the next meeting for the construction of the European Space for Higher Education, which will be held at Berlin in the present year [5], the education secretaries of the more than 30 countries which endorse this initiative will evaluate the achieved advances by each country and will establish the necessary agenda to overcome difficulties. The universities must admit the challenge and seriously work towards the realization of the different research and teaching activities in a new framework where innovation coexists with tradition and respect to heritage. The actual process has several purposes, among them there is to contribute to the social growth and to the training of the citizens with an increase of competitiveness at an international scale. Another objective is to establish an educational system of goof quality. To achieve these goals, several items must me adopted:
• New teaching methods for the comprehensive training of students.
• Common assessment and measure methods of the student learning (European credits: ECTS);
• Easily understandable documents with normalized formats for certificates and diplomas.

Inside this course of action, we consider that the mission of the university teacher is to focus in devoting special attention to the teaching methodologies; this cannot be taken apart from the practical assessments associated to these methods. At the end the teacher should enforce new perspectives aimed at the comprehensive training of students.

These objectives are favoured in our context in the Polytechnic University of Valencia by the Europe Project (Una Enseñanza Orientada al Aprendizaje) [6], which can be translated as “A Teaching Oriented to the Learning”. This project is an initiative of the Vice-rectorate for Student and Academic Co-ordination of the same university. This project was started two academic years ago with the top priority objective of focusing the teaching to the achievement of the know-how of the student.

MOTIVATION TOWARDS THE CHANGE

In order to understand the reasons behind the author’s group joining together with the objective of writing this communication, we need to briefly explain our situation as motivated teachers towards the continuous training and the improvement of the learning methods. In this way, we are actually participating actively in a specialized training program for teaching staff organized by our university.

It is commonly accepted that teaching in engineering degrees requires specific training. From this perspective, the Polytechnic University of Valencia in its Fifth Edition of the Initial Pedagogic Training Program (FIPPU) has gathered a group of novel teachers coming from different Technical Schools, Departments and backgrounds.

The FIPPU, organized by the Centre for Educational Sciences, is developed during an academic year and its main objective is to solve the problems, doubts and queries that arise in the learning situations. The teaching staff will receive answers and support according to his/her individual circumstance. Inside this Training Program we can emphasize the following activities:
• A full week long seminar: The Program is initiated with this activity that is held in a boarder regime, i.e. the participants spent the whole week together at a hotel in a location far from the city. The rationale behind this seminar is to promote the friendship and mutual exchange of experiences between the participants in a relaxed, out-of-the-norm work environment. Furthermore, the main schedule and basic contents of the Program are presented.
• Workshops and symposiums: There are training actions that are organized exclusively for the teaching staff that participates in this Program. The different workshops and symposiums go more deeply in the questions and problems that are more frequent in the teaching practice.
• Double tutoring: Firstly by the education specialists, members of the Training Program, which advise and stimulate the attitudes oriented to the improvement of the teaching methods from a more theoretical point of view. Secondly, by a “veteran” professor which tutors the teaching “apprentice” and that is directly related with the daily and pragmatic work both at the contents and knowledge levels.
• Recording of lectures: This is regarded as a very effective improvement strategy for the teaching practice. Generally, plenary classes are recorded for a later viewing and analysis by the teacher itself and by the Program group. This way, the teacher gains conscience of his/her strong and weak points in the different class situations.
• Meetings of the base group: The participants of the Program are separated in small groups of six teachers each coming from different knowledge areas and that are in a similar situation as regards to teaching experience. The objective of the base group is the mutual exchange of experiences and support.

From this situation and from a meeting of our base group arose the idea of participating in this meeting for: (a) to share academic experiences; (b) to enhance the teacher’s own perspective based on mutual interdisciplinary learning; and (c) to
carefully consider the diverse teaching methods and the methodological innovations used. This is all motivated by our own belief that the new European credits system not only implies a conceptual change that affects the students but a notable change in the way the teaching staff at universities works and how they face the training of the students.

**METHODOLOGICAL STRATEGIES IN ENGINEERING**

At the medium range teaching horizon, it is important a radical change in the teaching function, disregarding once and for all the figure of the “orator teacher” and to raise an image of the teacher as a “facilitator of learning” or a person that stimulates the students in the learning process. In the educative process the paper of the learning is gaining momentum, this learning was set aside by traditional teaching methodologies and teaching centred procedures. This means that we are witnessing to a substantial change in the way education is perceived: The student is going to be the centre of the process, the truly main character of his/her own learning. Obviously, the teacher has to adapt to this new situation.

In order to emphasize the cited leading role of the student, the teaching at every engineering has to take into account the practice factor and the way the practical knowledge is transmitted to the students. Like we have said, the teaching tools and methodologies have to adapt: The plenary class continues to be of interest and we cannot negate its utility, but all the learning-teaching process cannot entirely rely on it. It is true that a sound theoretical background is fundamental, but if we do not show real cases to our students or if they do not learn to put the theoretical knowledge into practice we will face strong resistance and a serious lack of motivation. It is very sad to hear from the students that they do not know the future use of a given subject or how a subject is going to help them in their future work.

To make the most of “classroom practices” in engineering courses is a very important factor, but how to get this practical component when giving theory classes? This clearly depends on the course and on the number of students, but in the same theory class we can reinforce the contents with practical cases or with a real problem, in such a way that the student can see that the theoretical contents of the class are very important and fundamental. In this case, the teachers that sign this paper have used this methodology in a variety of ways: (a) developing theory from a practical problem. (b) developing the practical cases while theory is explained, or (c) solving or proposing a real problem after the theory has been explained.

The resolution of real cases in theory classes or in lab classes facilitates the student the task of knowing the utility of what is being studied and this is going to greatly improve the learning process. Furthermore, the focus and correct approach of the real cases can notoriously help us in our labour. We have to make sure that the real examples are as real as possible as the engineer is going to work in a highly dynamic world and will have tonnes of information at his/her reach. This information will come from different, often contradictory, sources. The environment in which the engineer will have to take decisions is affected by social, politic, environmental factors, as well as many others. Today, the students do not learn these skills at the university. So our real cases cannot finish with the solution of complex mathematical models and with the comparison with the solution of a given theorem or with the optimization of a classical economic function with technical constraints since we already know that a real environment is going to be far more delicate and complex. We have to aim at obtaining the real cases from the daily life, from the press or from a nearer context.

This looks complicated but with a little training and observation of reality we can obtain real good problems for each subject, problems that we will propose at class. Now the work gets complicated again since we have to promote a debate, criticism, and a good engineering solution with tangible results. All of us that have tried a method like this one know that this type of teaching and learning poses a great deal of work for the teacher and a lot more time needed for preparing the subjects and helping students, but we also know that the students that get involved in this work routine will show a high performance and satisfaction. This way of working is not only useful for the students but also very gratifying for the teacher, since he/she will know that the future engineers (the students) will know what to do, or at least where to look for, when asked to solve a certain situation in the real world.

Seemingly important is to try to give to the student not only an exposition and the fundamental contents of the course, but also a good deal of additional information so the future engineers will know where to look and how to augment the already acquired knowledge if needed in the face of an eventual real problem in their future work life.

Another methodology that we can use to motivate and to favour the self-learning of the student is the visits to real companies or some conferences given by professionals of the field. This way, the student realizes that the subject that he/she is studying have not only a theoretical component, but that professionals apart from his/her teacher do apply this knowledge in the real daily work.

All these previous considerations take us to the point of defending the higher education at universities not only with the objective of training professionals with a given known set of theoretical and practical knowledge, but to the training of completely formed citizens, educated in all important aspects (social, cultural and professional). We think of the teaching practice as the integral formation of people, of the students, since the future engineer does not only have to have a degree under his/her arm, but a professional style, knowledge, attitude and ethics and with a work capacity that will allow him/her to adapt to the company. Summing up, we propose training based on three main pillars, which can be described as follows:
1. - Respect to the student, considering him/her like a person with the same rights and responsibilities as the teacher, placing him/her in the same plane of equality and never creating an image of a teacher being “superior” to the student.

2. - Promoting the criticism in the students. This is an aspect that many times the students lack of. It is hard to understand how the soon-to-be engineers never place objections to the ideas given in class. They always believe what is given in class as the absolute truth just because the teacher said so. What is even worse, they many times do not even have a formed opinion about certain social aspects in their environment.

3. - The use, in an flexible and open program, of parallel important issues that will help the student in the task of obtaining knowledge according to the current situation. This means that at least we have to contemplate three positive aspects:
   - Perception by the student and by the general society of a university that is close to the student and not lying in the past.
   - Innovation over the traditional education systems, which are, regrettably, still in use today.
   - Possible source of motivation coming from the use of daily important events in the classes.

   In this way, we think that it is utterly important to invest (not to waste) the first minutes in a class to ask the students ans to see how the learning process is going, really taking into account the student’s opinion. At every class we can make a relaxed feedback of what was seen at the previous class and, at this precise moment, insist in the main ideas and concepts that the students should learn. It is true that at the beginning the students may not be willing to participate, it will take some time before they feel confident to freely express their opinion. A good strategy to achieve this objective of participation is to allow the students to make slight changes of the program, or to let them try the allotted time for each part of the program. Obviously, all these techniques have a limit and we have to control the process so the students do not reach the false feeling that they control de learning process and the program itself.

   One way of putting into practice all the previous ideas is to open a forum at a plenary class and to let students give their opinion about the subject at hand, we will look for the spontaneous and repetitive reaction of the students, we will incite them to make questions and to freely express their opinions (always related to the subject, of course).

ASSESSMENT OF PROPOSED METHODS

This new teaching methods that we are defending have to go together with a new suitable student assessment methodology since there cannot be a separation between the teaching and assessing activities, in the case of the “classroom practices”, for example, the teacher can collect and correct the problems and at the following class there can be a forum of opinions where the correct answer is also given and discussed, this way the students will have a valuable feedback of the work.

In the case of guided visits to companies or conferences, we can ask the student to write a card with a summary of what he/she has learnt. About the weight of this kind of work in the final evaluation, not all teachers share the same view and have uniform criteria. Each professor gives to every work a given percentage on the final mark depending on the type of subject, or the general organization of the course (if there are other teachers involved and so on), or even taking into account a previous arrangement with the students.

The necessity of assessing the learning process in higher education cannot be argued, and this is independent from the methodology used, since the teacher has to certify the level achieved by the students and whether or not they have passed the different courses.

In our perspective, the student has the leading role in his/her education, and therefore, he has a very active function in his/her learning process. Why not let them participate in the rules of the game in the assessment process? We propose the following method, at the beginning of the course, in the first class, the teacher exposes his/her proposal for the assessment methodology, giving reasons for why that methodology is suitable for the class. With this new point of view we have to enforce the diversification of the assessment criteria (opens exams, objective tests, and practical work in groups…) and to disregard traditional methodologies of one single exam at the end of the course. This methodology has a major drawback as it is that the teacher will not have sufficient evidence to support the pass-fail decision in a subject. Additionally, we think it is important to make several tests and exams throughout the year to guarantee the accuracy of the final mark.

Summing up, we are going to synthesize the changes that we introduce in the assessment process as an evolution:

• From the use of a single method to the use of various methods of information collecting for the assessment.
• From the single student work assessment to the assessment of group work.
• From an assessment centred on the course to an assessment centred on items or program parts.
• From an implicit assessment to an explicit assessment.
• From an assessment centred in the knowledge to an assessment that will also consider abilities and capacities.
• From the normative assessment to the assessment based on objective criteria.
• From the teacher as the sole authority in the assessment process to the collaborative assessment.
• From the student as a passive subject to the student as an active subject.
• From the assessment as a routine to the assessment as a fundamental issue.

It is necessary to promote the dialog with the students and they have to feel that the teacher understands and accepts some of their ideas. This way, both teacher and students can reach a consensus in which both parts have actively participated and decided about the assessment process.

This methodology is being carried out by some of the teachers that sign this paper during this current academic year. The initial results and experiences are very encouraging, we have seen that the students seriously involve and participate in the classroom. We consider these results very positive.

CONCLUSION

In our work as teachers we have to train our students in such a way that they will acquire a structure of basic knowledge that will allow for the overall training that we have emphasized along this paper. This structure will be unfinished, but we will set the ways by which it can be completed in the future. Like it has been exposed, this structure does not only have to have theoretical knowledge, but also has to have social, cultural and ethical values. In order to promote this integral training we have proposed a change, both in the methodology and in the assessment process. With this change we look for the involvement of the student in the learning process and to make from the student the main character of his/her own learning process. This change means also a change in the way the teaching function is conceived and a great effort by the teaching staff at the university. This change looks difficult and might seem like the teaching staff may not have the ability to do so and that lacks the needed training background. However, all these difficulties should not make us detract from our objective.

We hope that the exchange of particular experiences of every member of the teaching staff that have participated in this paper will have continuity in the future. We look forward to work in the same productive, enriching experience with the aim of improving the quality of our teaching and, in the process, promote the learning of our students. Putting into practice the previously stated ideas dignifies the teaching work, this is one of the main reasons that support the idea that we are walking in the right direction.

REFERENCES


