Promoting Gender-Inclusive Activities in Engineering Education

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1. Introduction

Statistical data show almost equal proportion of male and female students at Mexican universities, although this proportion varies from year to year, from university to university, as well as from one academic career to another. In particular, there are 55% of female students at the National Autonomous University of Mexico, while there are 20 % of female students among all students that study engineering careers. In our career of Telecommunications Engineering, about 23 % of students are female. A relatively large number of female students in engineering careers results in rather common belief that gender-related issues do not exist in engineering education in Mexico.

2. Implementation of gender-inclusive activities

We studied current situation with gender equity in our career by means of a series of questionnaires. We also studied some background factors that may have contributed partially to the difference in preparation and performance of male and female students as engineers. The questionnaires addressed the degree of knowledge and practical experience of our male and female students in handling mechanical tools, mechanical and electronic measurement instruments, and basic fabrication processes and technologies. Also, we evaluated their self-esteem, self-learning skills, and leadership potential. We offered questionnaires to the students before and after our study.

The answers to the questionnaires revealed that 28% of female students had never used any mechanical tool or electronic measurement instrument before they entered the university; 70 % of female students had to make an extra effort in the beginning of the laboratory practices, because they lacked confidence in handling the laboratory equipment and materials; 13 % of female students had difficulties in integrating the knowledge acquired in particular subjects; 40 % did not like the role of a leader, and 42 % believed that men and women did not have the same opportunities while studying our career, because they occasionally felt prejudice and discrimination from either professors or male students.

The answers to the questionnaires of practicing female engineers revealed a widespread prejudice to female engineers. As one of the interviewed female engineers put it, “We female engineers have to know three times more than a male colleague in order to be accepted equally”.

Such a situation motivated us to undertake some measures in order to prepare our female students for future work much better than we did it before. We put forward a hypothesis that providing the female (as well as male) students with extra opportunities for developing their abilities and potential as engineers would have a significant positive effect on their future performance in engineering profession. The existing works address some gender-inclusive activities in engineering education [1]-[2]. However, we have not found recommendations on how to implement the gender-inclusive activities in the specific conditions of our career, university, and country. Therefore, we launched a study which was focused on finding the optimum forms of gender-inclusive activities in our conditions. We defined the objective of the study as follows: to establish and promote extracurricular activities that are aimed at providing female students with additional professional training, so that they face less prejudice and discrimination while developing their professional activities in highly demanding and competitive real-world conditions.

It is a common knowledge that academy does not accept radical changes. Therefore, we could only promote extracurricular activities at the initial stage of our study. As some previous studies showed a high educational efficiency of the Project Based Learning (PjBL) in our conditions [3], we employed this learning method for the implementation of extracurricular gender-inclusive activities in our career.

Within the frames of this study, a variety of teaching design projects was offered to the students of the 7th and next to last, 8th, semesters of the undergraduate studies. We explained the objective, gender-inclusive character, and potential benefits of such projects to the students. Following some preparatory work, the teams of mainly female students were formed. Each team consisted of three to four persons. Male students participated in some of the teams, but a team leader was always a female student. All teams had the same project topic. One of the most educationally successful project topics was development of an optoelectronic liquid-level sensor. Its success was due to the fact that it integrated in a natural way the topics previously learned in different subjects of our career, such as Optical Communications Systems, Digital Circuits Design, and Radio-frequency Electrical Circuits. In addition, the project involved a number of tasks that were not covered by the formal curricula.

The duration of the project was of 2.5 months. The students designed, implemented, and tested the performance of an operating brassboard version of a liquid-level sensor. They fabricated some elements and parts, assembled the device, tested it, developed progress reports and presented their work at a seminar.

According to the questionnaires that we used for evaluation of this activity, the students worked on the project for about 3 hours per week on average. They used Internet as the main source of information on different aspects of

the project. Each team gathered on a weekly basis to review and discuss project status and progress. Our professors consulted the teams on project-related issues, but did not supervise their activities too closely. Such policies stimulated students' self-learning, autonomy, and responsibility for achieved results.
In general, the students used the most straightforward technical solutions for the sensor. Many teams employed the light path interruption principle for measurement of the liquid level. The block diagram and electrical circuit of a typical sensor are shown in Figs 1 and 2, respectively.
Some other teams employed a change in optical refraction in liquid media for liquid-level measurement. The latter type of sensor turned to be more complex, but less sensitive to the environmental light than the former sensor type. A variety of operational principal and particular technical solutions that different teams employed in their projects made the given activity more competitive, interesting, and educationally useful for all participants.
About 80% of the teams completed their projects and developed the functional devices that satisfactory measured the level of a liquid in a small reservoir in laboratory conditions. The rest of the teams did not reach the final goal, but acquired a lot of useful experience in the development of real-world devices.

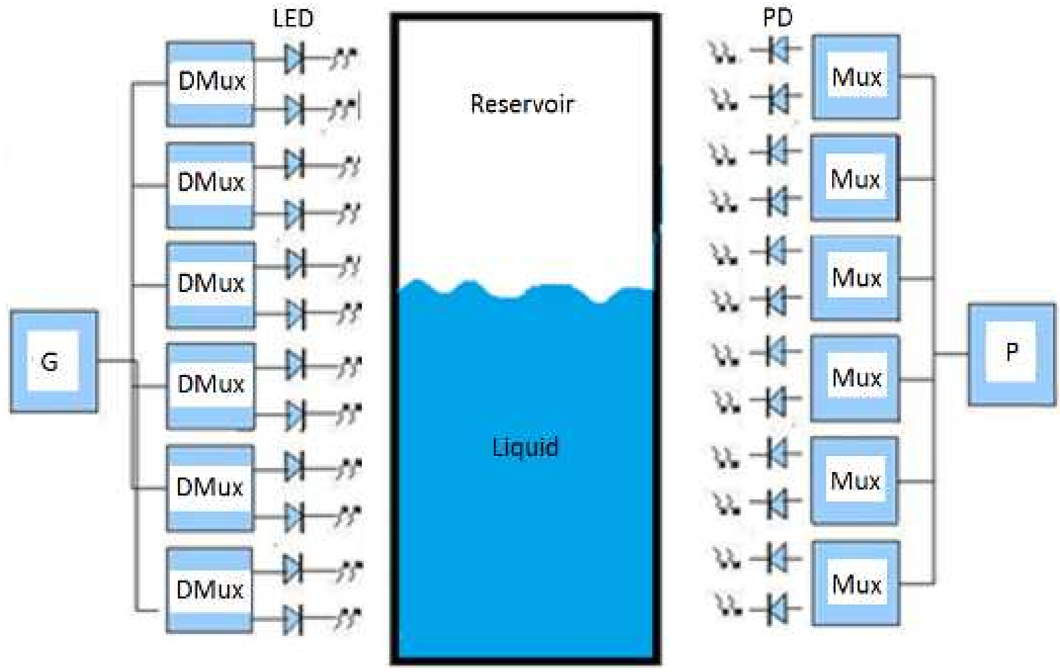

Fig 1. Block diagram of discrete optoelectronic liquid-level sensor based on the interruption of the light path by a liquid. G – Pulse generator, DMux – Demultiplexor, LED – Light emitting diode, PD – Photo diode, Mux – Multiplexor, P - Processing and display unit.

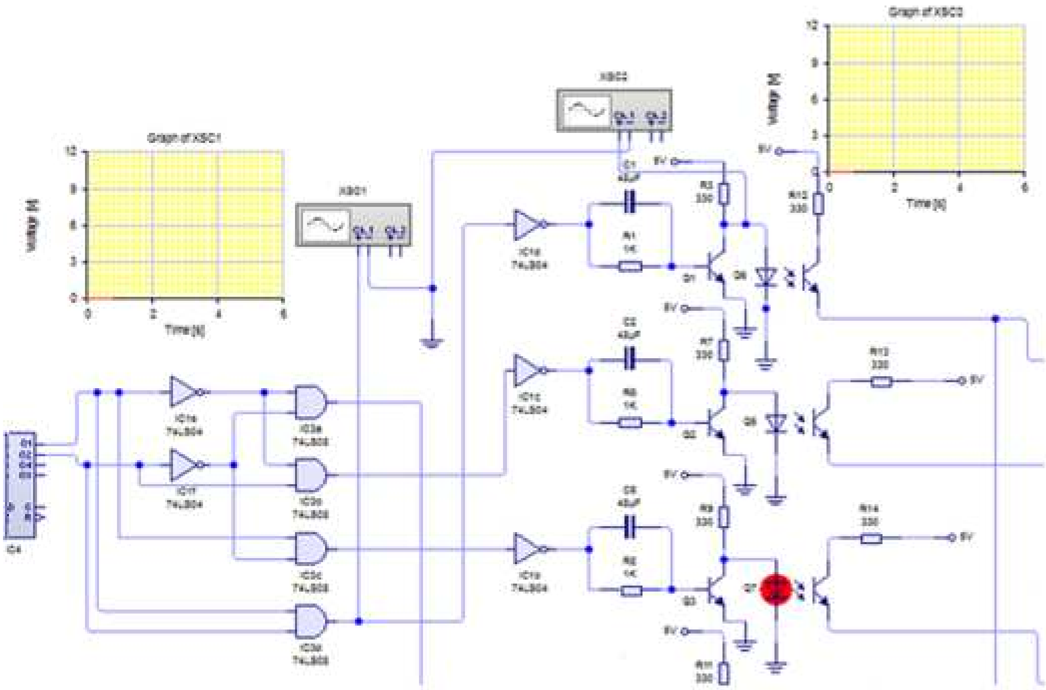

Fig 2. Simplified circuit diagram of the liquid-level sensor.

3. Educational results

The educational effectiveness of these projects was studied by means of surveys that were focused on the new knowledge, skills and abilities acquired by the students.
More than 90 % of male and 95 % of female students considered that they acquired significant new knowledge on the use of different materials, design and fabrication of electronic circuits, use of mechanical and electronic measurement instruments, as well as a valuable experience in identification of different design faults. All female students (100 %) acknowledged enhanced confidence in their performance as engineers. They related this fact to a wider experience in handling of diverse measurement instruments and tools, such as electrical current and voltage supplies, oscilloscopes, millimetres, etc., and to the practical experience acquired in the design and fabrication of different elements and complete sensors, and installing them in the reservoirs, sealing the joints and so on.
More than 50% of female students considered the project the most educationally significant element of the curricula.

4. Conclusions

Our results show that educational activities of this kind are highly effective in preparing female students for future work in competitive and stressful situations. The Project Based Learning helped enhance confidence of female students in their performance as engineers. Within the frames of PjBL, the female students had adequate conditions for the development of creativity, initiative, and other personal qualities that are highly valued by the engineering community. The complimentary benefits were enhanced self-learning skills, team work experience, elaboration of coherent, well-structured technical notes and reports, and training in time management. Also, the PjBL helped bridge the existing gap between the academic training and real-world experience, develop professional customs and prepare participants for interaction with the industry. As a result, self-esteem of the female participants increased, as well as their capacity to perform effectively in real-world conditions, including competitive and stressful situations.
An additional positive result of this activity was an increase in the number of female students who decided to study for M. Eng. degree after completing the undergraduate studies.

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