LEARNING DIGITAL DESIGN THROUGH ROLE PLAYING

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ABSTRACT

This article presents an experience carried out by the Digital Systems area in the Electronic Engineering program, using problem-based learning (PBL) and mobile technologies. This assessment makes use of both the concept of learning and the professional profile of electronic engineers proposed by the MIMESIS Research Group and CDIO Initiative, in order to present project-based learning as the didactic strategy underlying this experience. Results are presented based on two dimensions: first, the interactive dimension, which encompasses the flow and the kind of communications established between the students along the process, enhancing their interpersonal abilities. Second, the pedagogical dimension, which makes it possible to assess the experience bearing in mind three criteria: motivation, learning and collaborative work. Additionally, a number of factors which can explain the results are identified.

KEYWORDS

Problem based learning, teaching in engineering, electronic engineering.

INTRODUCTION

Advances in both technology and complex digital systems demand design-related competences on the part of electronic engineering professionals. The development of such competences must be encouraged since the earliest stages of their professional training. In order to respond to these challenges, the Digital-Design academic subjects in the Electronic Engineering Program at Pontificia Universidad Javeriana were modified in both their methodology and contents. The digital design subject, which is part of the program's training core, is to be taken during the seventh semester in a five years program. In terms of methodology, the style of classes changed from lectures to project-based sessions, where collaborative work, knowledge development and professional-competence acquisition are stimulated [6].

In order to promote the development of basic professional competences, a number of professional life experiences focused on the electronic solutions industry were integrated into class sessions. This was done bearing in mind that products in this area are developed by task groups with specific functions, and that the complexity of designs demands collaborative work among engineers who are significantly distant from each other; it demands efficient communicative processes which enable different groups to reach high-quality outcomes. This led to the development of "role-plays," a didactic strategy which is useful for an appropriate development of electronic engineering tasks.

The project-based learning component covered the CDIO cycle: conceive design, implement and operate a digital system [1] [2]. It was developed by teachers at the Electronic Engineering Department at Pontificia Universidad Javeriana, Bogotá (Colombia), together with the MIMESIS Research Group which coordinates the CDIO reflexion.

ROLE-PLAY DESCRIPTION

The role-play designed simulates real-life conditions in the development of digital systems, as a real CDIO experience, where interaction between designers and architects takes place in the distance, and where each participant has independent tasks to carry out [4][5]. Two roles were defined in this activity: architects and designers. Distance between these groups of professionals was simulated by involving two class groups, each with different teachers and class-schedules: groups A and B. Two or more projects are proposed so that architects are part of group A and designers are part of group B. Roles are shifted in the second project so that everyone can be both an architect and an engineer. Participants must change counterparts too in order to expand the range of communicative interaction.

The game is scheduled to take place during the last five weeks of each semester. First, the systems to be designed are proposed as if they had been requested by a client. All the groups take the role of architects and produce system specifications, the blocks diagram, and the timing description of the system. This stage lasts two weeks and a half, and is carried out in and out of the classroom.

Once the architecture stage is over, each group sends documents to their designers via the Blackboard® platform. Then all groups become designers, and their first task is to review the document describing the architecture of the system. Doubts and questions arising from this preliminary review are addressed to architects, who then make corrections and provide further information in order to continue with the development of the project.

Designers describe the system hardware using AHPL language [3], and then develop a diagram based on the specifications provided; after that, they describe the system using VHDL language, and finally it is both simulated and implemented using the programmable logic device. A record of the interactions between groups is kept in order to follow up the learning process, the quality of their work, the most common doubts and the answers provided by each group. This is all documented in order to gain a comprehensive picture of the activity.

In order to follow up and classify the interactions that take place between architects and designers, an online discussion forum was created. Additionally, a taxonomy comprising all the possible forms of interaction was created in order to classify the actions taken by groups in the forum. This record makes it possible to identify changes in interaction along the experience.

INTERACTION TAXONOMY

During the first semester 2009, the records of an experience carried out showed a total of 121 interactions between the 18 groups involved. First, such interactions were analyzed by the research group. Then, they were classified based on the communicative objective designers had in mind. Once this taxonomy was established, it was used to identify forms of interaction in forums. This information was the basis for the study of developments in a number of communicative abilities, and for the analysis of learning achievements.

Interaction by students was classified into categories based on the kinds of requests they made. Each interaction category was defined as follows:

Information requests: when data are needed.

Argument requests: when the criteria followed by designers and architects differ concerning proposals by the latter.

Clarification requests: when a designer is not clear about the proposal given by an architect.

Proposal requests: when designers present architectural solutions or modifications once they find a possible error.
Replies by architects were classified bearing in mind emerging categories based on analysis by researchers. The following categories were identified:

Information replies: they limit themselves to data transmission.
Correction-based Information replies: they are correction-geared procedures that are based on the absence of information in a given specification due to a conceptual error by architects.
Informative replies that generate self-correction: they happen when information requests by designers cause architects to detect errors which had not been identified before.
Clarifying replies: they explain design choices based on criteria and concepts learned in class.
Argument replies: they generate debate.
Teacher-mediated replies: they take place when a debate does not reach an agreement.
Empty replies: they take place when architects tell designers to review the document provided without offering any further information.

Interaction analysis, that is, the process of requesting information and providing a reply, provided the basis for defining classification according to the effect of each interaction in the development of the project. The following are the categories identified during the analysis of interactions on the part of researchers:

Informative interactions: those geared toward information transfer.
Correction-geared interactions: they generate the need to reflect and study on the part of architects. They seek modifications on the solutions and choices originally proposed during the architecture stage.
Clarifying interactions: they are geared toward explaining and complementing a description.
Self-correcting interactions: they help architects find errors that need to be identified. They are different from correction-geared interactions because they do not take place after requests by designers.
Empty interactions: those where there is not any valuable information exchange.
Argument interactions: those that generate debate between architects and designers.
Corrective-collaborative interactions: they are geared toward correction and rise from a designer's proposal, rather than from a designer's request.

EVALUATION OF INTERACTIONS

At the beginning of the experience, a high percentage of clarifying, informative and correction-geared interactions take place. This can be explained given the low quality of initial descriptions by architects, in terms of clarity and completeness. In most cases, low levels of writing skills were identified. The highest percentage of interactions was that of correction-geared interactions, which indicates self-regulation by groups. In time, self-regulation became evident through Self-correcting interactions, which means that architects themselves identified their own errors as a result of receiving inquiries by designers while reviewing architectural proposals by other groups. The need to put proposals in writing in order to facilitate comprehension became evident as well. This gradually strengthens communicative abilities.
The analysis of Figure 1 makes it possible to verify that, in time, there was a decrease in clarifying, informative and correction-geared interactions. This indicates that the corrections made provided adequate responses to feedback by designers, providing them with appropriate tools to carry out their implementation work. Debates or argument interactions emerged mostly when both designers and architects had acquired conceptual tools to assume a stance and defend it, as well as to recognize their own errors. All groups showed a tendency to reach consensus. Role-plays permitted learning to evolve, which was observed

in Corrective-collaborative interactions that took place when both roles had enough conceptual elements to carry out a debate. The design group could make proposals and, together with the architects, they found the best solution to develop each project. This was verified in the project assessment meetings, where both architects and designers were present.

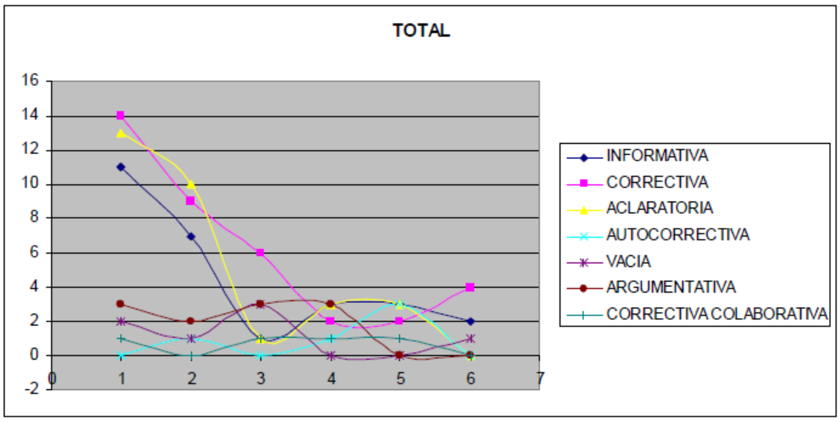

Figure 1. Interaction patterns

Architectural proposals which were adequate since the beginning did not require many interactions, since they were clear and complete. This could be seen in the interaction forum. On the other hand, a number of proposals needed several modifications during the activity due to their defects or conceptual errors.

It is worth stressing that, by the end of the process, all the designs were fully functional and met the requirements previously established. This makes it possible to infer that all the groups evenly reached objectives at the level of content, and that they attained course objectives in a collaborative way. This does not mean that all the architectural proposals and the organization of the systems presented were identical, since each architect/designer pair found solutions with significant differences. The main differences were proposed at the level of the internal organization of the blocks that constitute each system.

EVALUATION RESULTS

The experience in the Digital Design subject was evaluated by students through self-reports that dealt with achievements made in terms of motivation, collaborative work and learning. Students had to evaluate each one of these factors based on a scale from 0 to 5.

Response percentages were calculated based on the number of responses given by all of the students who carried out the evaluation (70). The grade obtained on each factor evaluated corresponds to the average grade given by students.

Factor No. 1: MOTIVATION. Average grade: 4.53/5

Among the three factors evaluated by students (motivation, collaborative work and learning), motivation got the highest grade. This can be seen through an increase in attendance and participation on the part of students. The effective use of class time was also a motivating factor due to timely clarification processes, to access to relevant information in the forum, and to the use of the tools available both in classrooms and the laboratory.

Factor No. 2: COLLABORATIVE WORK – Average grade: 4.35/5

Collaborative work received the second best grade in this evaluation process. Students particularly identified the strength and usefulness of interactions between work pairs and between students and the teacher. This explains the increase in participation. A number of

students developed motivation toward team work and, in general, there was an atmosphere of collaboration and respect among participants.
With regard to communicative processes, students emphasized both the clarifications provided by the teacher and the efficiency of the process. This facilitated comprehension and concept assimilation. Technology and software tools played an important supporting role in these information exchanges.

Factor No. 3: LEARNING – Average Grade: 4.3/5
Class didactics contributed to learning, particularly in the practical application of concepts. Students stressed the usefulness of student-teacher interaction, since they could timely obtain clarification about key concepts for the development of the project.
Access to information obtained the third place among the factors that favor learning. It enriched interactions and was managed so that information would be, not only transmitted, but understood and applied to the solution of problems.

CONCLUSIONS

Conclusions are given at three levels. First, the contribution of this CDIO experience in the training of students through an exercise which is similar to the situations engineers normally face in their work life. Second, the impact of this proposal on motivation toward learning: it fosters autonomous learning, as an essential personal competence. The third aspect is the contribution of this process to the assimilation of concepts, which became evident in the results shown by the groups involved. Conceptual clarity was evident in both discourse and written reports.
Concerning the contribution by this experience, results make it possible to state that the proposal promotes the development of skills which are considered fundamental in the curriculum for future performance in Digital Design. Students assume the roles of architects and designers, which are involved in real situations, and enhance both writing and debating skills through written reports and forum discussions.
The importance of collaborative learning also becomes evident, since it contributes to the identification of individual strengths and to joining efforts. Collaborative work is an essential element in the development of interactions between work pairs, and helps in the assessment of the nature of intervention by students. Even though at the beginning there is a high number of communications geared toward correcting the work carried out by other people, and toward requesting information, the process here described evolves into self-correcting interactions.
By the end of the process, most designs are successful. This reflects the importance of collaborative work between work pairs in order to make progress in learning, concept assimilation and problem-solving skills. Each architect/designer pair creates and implements solutions which propose alternative paths of action that respond to the objectives established for the project. This stimulates creative and divergent thinking, as well as a change in the understanding of the discipline itself.
Among the three factors evaluated by students during this experience (motivation, collaborative work and learning), the one with the highest rating was motivation. Students showed an increase in attendance to class sessions, a higher level of participation in activities, and a better performance during the tasks assigned. It also has a positive impact on concept assimilation and work quality.
It is worth emphasizing what students pointed out concerning the importance of timely feedback on the part of the teacher and immediate access to relevant information, which are directly related to the comprehension and assimilation of technical concepts. These are two key factors that make it possible to go from a mere transfer of information to a real comprehension process which helps solve problems, developing the professional attributes of an engineer. The role of technology in this kind of experience is also stressed, since it is a supporting tool that permits a better use of class time. Likewise, technology makes it possible to share individual contributions and feedback with the whole group.

The interactions between students are important evidence of the transformations that can be generated through an experience of this nature. The process begins mainly, with interactions of informational nature, and then problems of conceptual clarity and writing-reading problems are evident. As the project develops, the predominant interactions are corrective and argumentative type. At the end of the project, most of the interactions are self-corrections, showing that the concepts have been learned.

A particularly important achievement was the writing practices of students, who could make a metacognitive view of their forms of writing, when their receptors became obvious confusion in the text of the instructions. This situation helped to achieve greater precision in the specifications, so that gradually the records of the interactions between students can see a decrease in corrections and a more favorable response from the designers to meet the specifications of architects.

Finally, this work assumes the challenge of creating conditions for keeping the quality of results during the time frame assigned to the goals proposed. It also stresses the importance of strengthening interaction processes between pairs. There is a high need of both curricular changes and transformations in teaching practices, which tend to be deeply rooted in the individual experiences of teachers and in the story of the discipline itself.

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