How Can Biomedical Engineering and Health Science Students Learn Together?

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Abstract— **The aim of this study is to pilot test the active learning techniques we have developed to promote interdisciplinary work in students from Biomedical Engineering and Health Science programs. A combination of an only post-test one-group design using a survey with a descriptive analysis of the students' perceptions of the learning strategies was used during the course using a group interview. As a result, the students believed that the ASSI-TECH course contributed to the creation of communities of practice, they were satisfied with their learning processes, and they valued the active and collaborative learning activities.**

Keywords— **Engineering education, interdisciplinary work, professional skills, active learning.**

I. Introduction

The current practice of any professional involves interactions with other professionals from different disciplines. This situation requires the development of skills for multi and interdisciplinary interactions at university. In spite of this, few courses are designed to foster the development of a skill for integrating students from different disciplines, and it is not common to find courses that are designed with an interdisciplinary approach. In other words, students do not easily find courses where they carry out real interdisciplinary work with counter pairs from other careers; although in their professional lives they have to address problems in interdisciplinary teams, this situation made them feel unprepared for it [1].

Besides, it is common on elective courses to find students from different courses and semesters (Freshman, Sophomore, Junior, etc.). This is challenging for teachers as they have to adapt their lectures, labs and other learning activities to achieve a genuine integration of all the students in the proposed learning activities. If a teacher uses traditional 'passive' learning techniques, where students simply take notes or just listen to the teacher's lecture, the learning outcomes obtained at the end of the academic process are not exactly the best; moreover, the students' potential is not fully exploited. Despite sharing the same classroom, they usually fail to experience interdisciplinary work. On the other hand, if a teacher uses active learning techniques or collaborative learning techniques it is possible to create natural critical learning environments [2]–[6] to improve the students' performances. There is evidence that using active learning techniques is critical in two ways: the improvement of critical thinking and problem-solving skills, and increasing the likelihood that a student will finish his course (reducing attrition) [5]. These student-centered environments provide the opportunity to try, fail and try again before any evaluation, as well as providing the opportunity to close the gap between the current and desired student performance [7]. In addition, collaborative learning techniques foster the generation of Communities of Practice [8].

Another important context to highlight is that currently the professional market is increasingly competitive; however, on average worldwide 35% of business managers have difficulty filling vacancies (the average in Colombia is 30%) according to the results of the Manpower Talent Shortage Survey 2013 [9]. This study states that the main reasons for this difficulty are a lack of the candidates' technical skills (34%), shortages of candidates (32%) and a lack of experience (24%). According to the Labor Observatory for Education of the Ministry of Education in Colombia, when the Labor Observatory asked 2013 graduates the question what the main difficulty of getting the job they had been looking for was, 44.6% said they did not have the experience required for their target job [10].

The situations described above show an urgent need to improve the acquisition and strengthening of skills for problem solving in interdisciplinary groups, thus promoting the tangible application of the knowledge acquired by students. The present paper reports the advances in this direction by means of a strategy which promotes interdisciplinary work in Biomedical Engineering and Health Science students. The course selected for this purpose is called ASSI-TEC01 which main topic is assistive technology (AT). AT is any tool that an individual with a disability uses to accomplish something that would be difficult or impossible for him or her to do without using that tool [11]. Thus, AT increases the capabilities of people with disabilities. The importance of developing skills to work on interdisciplinary teams is overt in the field of assistive technology due to the fact that developing useful and usable assistive technologies often presents complex challenges that require input from multiple disciplines and sectors [11].

I. Torres et al. (eds.), *VII Latin American Congress on Biomedical Engineering CLAIB 2016, Bucaramanga, Santander, Colombia, October 26th -28th, 2016*,
IFMBE Proceedings 60,
DOI: 10.1007/978-981-10-4086-3_13

The aim of this study was to pilot test active learning techniques we developed to promote interdisciplinary work in students from Biomedical Engineering and Health Science programs.

II. Materials and methods

A. *Study design and measures*

The constructs measured in this study were Satisfaction with Learning (SL) and Communities of Practice (CoP). For this study, the construct SL is defined as the extent to which student perceive how well a learning environment supports academic success in a given topic or field [12]. The construct CoP (or learning communities), is defined is the extent to which students perceive they are part of a community of peers who share interests and work together to learn and achieve professional growth [8].

For this pilot study the authors used a combination of an only post-test one-group design using a survey with a descriptive analysis of students' perceptions of the learning strategies used during the course through a group interview. A 7-point Likert scale with 36 items grouped into three sections was used. In the first section we asked for the participants' demographics and program. In the second section we inquired about whether or not the students' used the open access technologies we had used during the course in their clinical or hospital fieldwork with people with disabilities or on other courses. In the third section we created specific questions by adapting the scales and items already validated that measured the two constructs SL and CoP. SL included items related to students' satisfaction with the materials, equipment, activities and instructor's support, as well as motivation and sense of control on their learning process. CoP included items related to students' connectedness with peers and instructors. Each item had the same weight into each construct. This survey was used in previous research with students on a master program in Occupational Therapy [8]. Additionally, a semi-structured interview was designed for this study in order to assess the students' perceptions with the active and collaborative learning activities implemented in the ASSI-TECH course.

B. *Participants*

In this pilot study all the students enrolled on the ASSI-TEC01 course in one term (n=5) participated.

C. The ASSI-TEC01 course: our proposal

The ASSI-TECH is an elective course offered to students during the last two semesters of their courses. Although the University teaches in Spanish, this course is taught in English because to obtain a degree students have to achieve a certificate at B2 proficiency level in a foreign language (English). Thus, besides teaching the content of Assistive Technology, this course is intended to promote the use of English as a second language with academic purposes. ASSI-TECH is an elective course with 3 academic credits and 48 hours of work per semester. It is offered by the Rosario University and it focuses on the implementation, adaptation and development of assistive technologies for people with a disability.

In this course we implemented strategies for the use of active learning techniques that promote interdisciplinary work. The activities were designed to improve skills such as: communication with professionals from different disciplines, hands-on skills, working under pressure, problem solving and communication in an academic environment. These active learning activities were accompanied by lectures and laboratory work with content on assistive technologies such as AT definitions and classifications, statistics about people with disabilities throughout the world and in Colombia, the International Classification of Functioning, Health and Disability and Human-Technology Interfaces.

The active learning activities used during the course were the following:

Introduction activity: Noodle structure is an activity used to integrate working groups and to discover skills like competence, leadership and others [13]. This activity was used to introduce students to the philosophy of interdisciplinary work. The course is divided into groups and each group has to build a stable structure with noodles and pieces of duct tape; the structure must be constructed in horizontal direction and attached to the edge of a table. The requirement is that the structure must be elevated without coming into contact with the floor.

Case Study: In the second session a case study was assigned to the students. This case study was about a person with a severe motor impairment who required assistive technologies. Students had to use this case study throughout the whole course. At the end of the course the students had to design an assistive technology device for the person in the case study.

Role-play: This was an activity in which students simulated different roles: patients with disabilities, health or engineering professionals, patients' families and social services professionals, all in a real-life situation. The students prepared their role-play based on the previously assigned case study. The play had to be as real as possible. The final aim is the students' awareness of 'real' professional experiences as well as the needs of the patients and their families.

Hands-on Technology: This is an activity where the students find out about, set up, test and compare different technologies with a specific aim. In this case, the students compared their performance by writing a text using different methods for accessing a computer such as head trackers, adapted keyboards and keyboards on the screen.

Hackathon: In this activity the students had to solve a real technical problem in limited time. Similar to the *Hands-on Technology* technique [14], with this activity the students could

gain a more in-depth understanding of the concepts related to conceiving, designing, constructing and testing a low-cost assistive device (Fig. 1). This is an example: "*TASK: You will have the challenge of creating a device as an assistive technology. The device will allow you to emulate the left mouse click in a person with reduced mobility by means of a 'switch'. You have three hours to finish the activity. You can use the elements provided (e.g. springs, magnets, levers, aluminum bars, Arduino boards, and electronic elements and sensors). The design requirements are: the device cannot use batteries, the device should be as small as possible and the device should be as cheap as possible. You have three hours."*

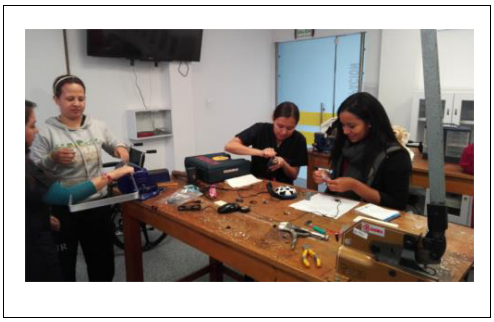

Fig. 1 Students working in a hackathon.

D. *S*tatistical analysis

In order to respond to our research question: What were students' perceptions of Satisfaction with Learning and Communities of Practice on the ASSI-TECH course?, descriptive statistics were used. The mean and standard deviation of the constructs SL and CoP were calculated. Mean values of these constructs higher than 5 points, indicate good perceptions with the active and collaborative learning activities on the ASSI-TECH course (i.e. seven point Likert Scale was used to measure Communities of Practice and Satisfaction with learning constructs students' perception). In addition to that, a Spearman correlation between CoP and SL constructs was calculated. We expected a positive correlation between these two constructs. The alpha level of significance for all the tests was set at $p \leq 0.05$ (two-sided). The SPSS V 22.0 statistics package was used to generate descriptive, univariate, and bivariate statistics, respectively. We used non parametric statistical analysis in this pilot study due to the ordinal nature of the variables and because our goal was to identify some hints about how the constructs SL and CoP behaved under the learning environment created in the course.

III. Results

A. Participants' description

All the students were female. Three of them were from Occupational Therapy, one from Psychology and one from Biomedical Engineering.

B. What were the students' perceptions of Satisfaction with Learning and Communities of Practice on the ASSI-TECH course? (from the survey).

The means and standard deviations of all the items or questions from both the Satisfaction with Learning and Communities of Practice constructs were calculated. Also, a summative scale with all the items or questions from both constructs were calculated, and then the mean and standard deviation of this new scale were calculated.

Regarding Satisfaction with Learning, the mean and SD of all the items were 6.49 (SD=0.74), while for the summative scale they were 110.4 (SD=5.98), which means that the Satisfaction with Learning construct measured by 17 items (maximum possible score 119) was located in the highest third of the summative scale. This indicates that students' satisfaction with learning on the ASSI-TECH course was high.

In relation to the Communities of Practice construct, the mean was 6.58 (SD=0.67). The mean and SD of the summative scale were 79 and 3.94, respectively, which means that this construct measured by 12 items (maximum possible score=84) was located in the highest third of the summative scale. This reveals that the students believed that the ASSI-TECH course contributed to the creation of communities of practice.

Finally, the correlation coefficient (r_{xy}=+0.945, $p<0.016$) indicates that as the perception of the Communities of Practice increases, the Satisfaction with Learning increases as well, and vice versa.

C. What were the students' perceptions with the active and collaborative learning activities implemented in the ASSI-TECH course? (from the semi-structured interview).

Introduction activity: The Health Sciences students perceived that their first natural reaction before this activity was to rely on the engineering students; however, as the activity progress they realized that their own ideas were valuable and useful for solving the problem.

Case Study: The students perceived that having a case study throughout the whole term increased the meaning of what they were learning because they had a tangible purpose associated with their learning process. The students valued the opportunity to contribute to the solution of this case study from their own careers.

Role-play: The students found this activity to be beneficial for their learning because they had the opportunity to reflect on the feelings, concerns and frustrations of a person with a disability and his or her family. The student in the role of the person with a severe motor impairment said that she felt she was able to understand better the needs of an individual with a disability after this class. The students commented on the importance of involving caregivers and relatives in the decisions about the design and development of an AT device. A student from the Biomedical Engineering program played the role of

Biomedical Engineer. She commented that she felt a big responsibility when the family of the person with the disability asked her about the best technical features of an AT device for their relative. The students also commented that they valued this learning strategy because they had the opportunity to put themselves in "*another's shoes*".

Hands-on Technology: The students valued the opportunity to use and experience different types of AT. They liked the method of comparing their own performance while doing the same activity using different types of input control interfaces.

Hackathon: The students commented that they felt pressed for time during the activity. The most difficult aspect of the activity was to decide quickly how to solve the problem. However, they valued working together to find a solution for the challenge.

IV. Discussion

The strong positive correlation between Satisfaction with Learning and Communities of Practice and the interview results indicate that the students were very satisfied with the learning process on the ASSI-TECH course. This is because they had opportunities such as creating a community of practice around the project they developed as they learned from and taught their peers, and playing the role of AT professionals (e.g. Occupational Therapists, Biomedical Engineers, Psychologists and Social workers), individuals with a disability, their caregivers and relatives. The students' comments during the course provided us with hints that they were working with an interdisciplinary approach, which is critical in the field of AT [11]; for instance, near the end of the course, one of the Occupational Therapy students said during a follow-up meeting "*... We just adjusted the sensor sensibility this morning and now our device is working*". This expression allowed us to see that Health Sciences students were committed to solving the technical problems at the same level as the Engineering students.

V. Conclusion

After conducting the pilot study the authors were able to reach the following conclusions: (1) The students believed that the ASSI-TECH course contributed to the creation of communities of practice; (2) the students were satisfied with the learning process during the ASSI-TECH course; and (3) the students were satisfied with the active and collaborative learning activities because they had the opportunity to create a community of practice around the project they were developing. These results encourage us to continue with this strategy in the future with larger courses.

Acknowledgment

The authors want to thank the students from the ASSI-TEC01 course for their participation in this project.

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Conflict of Interest

The authors of this work declare that they have no conflict of interest.

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