Research in and outside the classroom: training engineers without borders

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ABSTRACT: *Engineers without borders* is based on education for development, in order to form a global professional with the capacity for action, committed and knowledgeable about the issues and challenges of a globalised world. This study is supported by Edgar Dale's Pyramid of Learning and provides an overview of the development of skills from the project-based curriculum planning, constructed on a ludic and motivational approach to teaching geology to third-year civil engineering students. The purpose of this active methodology was to encourage students to acquire both soft and hard skills, which were evaluated through practices conducted in the field by theoretical and technical activities. From the results obtained, it can be interpreted that students had good expectations and felt fully motivated with respect to the skills achieved. Similarly, it was evident that students have good intellectual capital, but with weak non-technical skills.

INTRODUCTION

Students choose to obtain a university degree in engineering for a variety of reasons determined by their aspirations, ability and/or university place availability [1]. In fact, an important dimension of quality in higher education is the quality of the outcomes achieved [2]. In the absence of formal preparation for teaching in the university context, faculty (academic staff) commonly learn by experience, reflection on that experience and some form of mentoring. Faculty development programmes have traditionally focused on *how to teach*; that is, on techniques and tips conveyed into workshops or through individual consultations that have been reported by several authors [3-7.]

The mission statements for most colleges and universities include the goals of lifelong learning, critical thinking, autonomy and student empowerment; in this practicum setting, the educational process should not be converted only into a proposition of tautological concepts [8]. Nevertheless, in this context, occasionally university teaching becomes a secretive profession. The classroom remains a private space where colleagues rarely drop in to observe or share methods and strategies about teaching that will guarantee increased student learning and cooperative learning abilities [9]. Accordingly, Craton and Carusetta explain that teaching is a specialised form of communication with the ultimate goal of fostering student learning to acquire first-rate knowledge [5]. But, the main question is still …*how to teach?*

This has been a major issue in the debate on how to raise standards in education. Despite these comments, the best teachers tend to be those who think about what they want to accomplish, how they are going to accomplish it, why they want students to learn and how they will know that students have learnt. On the other hand, depending on the overall changes, international treaties, changes in the roles of university-industry-state, and the way knowledge is acquired and the learning processes that develop are indications that engineering education should cover a set of learning experiences that enable students to build a deep range of knowledge, to develop their skills, techniques and professional proficiencies and apply them to a large number of educational projects in engineering [10].

The current demand for engineering education has been questioned from different angles, but engineers have distanced themselves from the *real* world in recent years, as there is an apparent tension between two irreconcilable needs. On the one hand, there is the need for engineering graduate students to master a wide range of expertise, and on the other hand, the there is also a growing need for young engineering graduates to possess attitudes, attributes and personal and interpersonal skills that will enable them to develop successfully in the professional world and be able to design, produce and manage new products and/or systems [11].

Within engineering, pedagogy should be aware that students learn in many different ways: by seeing, hearing, thinking, acting, drawing analogies and building mathematical models in the area of science and technology [12]. That is why several studies and initiatives have been developed to recognise, identify and recommend what should be the most appropriate practices and criteria for curriculum changes in engineering education worldwide [13]. However, all these studies seem to agree that it should encourage more student-centred learning, to create a more interactive and motivating learning environment for both students and teachers themselves [14].

At this level, it is extremely important to establish processes and interactive episodes between student - teacher and among the students themselves, by the fact that knowledge is not only the direct interaction of the subject, but also participating in the acquisition of learning is essential.

In this vein, the present study's main purpose is to present a discussion of some elements of the dynamics of the play activity for teaching and learning engineering competition called *Student Contest of Survival Engineering* (SCSE) - in the context of the co-construction for the appropriation of significant learning in the Geology subject at university level.

The ludic activity proposed as a pedagogical pillar is based on the constructivism and grounded in project-based learning (PBL), and supported by the Edgar Dale's Pyramid of Learning where those involved in the process of teaching and learning are encouraged to participate in the construction of meaningful learning in a dynamic environment, through the development, training, generation and promotion of *soft and hard skills* and future contrasting with other learning practices for engineering education.

MATERIALS AND METHODS

The research undertaken is descriptive, analytical and cross-country type. A detailed study was conducted to determine whether any *soft and hard skills* can be generated in students by conducting ludic activities in the field, day-out class.

Definition and Characterisation of the Object's Study

This study was developed within the scope of the subject of geology, for the second semester of the third year of the civil engineering programme. The overall objective of the course is to train future civil engineers capable of understanding the importance of solving geological problems in the civil engineering environment.

The planning of the course is based on PBL in which the realisation of a series of activities throughout the semester are scheduled: academic activities inside - master class - and outside the classroom - day out; demonstration laboratories, field trips and technical tours, documentaries and reading technical reports supported the use of OER (open education resources) [15] and the realisation of a project to complete the course. Additionally, mobile technology tools, smartphones (with free apps) and software were used for the purpose of the formation of the engineering student. Students were informed of the skills developed assessments by the teacher on the completion on the first *Student Contest of Survival Engineering* - SCSE during Expogeologira (geology tour), during which conducting field work was scheduled over three consecutive days. The students were grouped into five teams for the achievement of the different practical and theoretical activities appropriate to the subject.

In this activity type day out, different teams had to run and deploy the engineering practices that they had acquired throughout the semester in the field, accompanied by the observation of generic skills. Thirty-nine students were enrolled in the course in Semester 2, 2014.

Assessment Criteria and Skills Distribution

The teacher evaluated proven competences in the field, along SCSE and they were divided into two groups: soft and hard skills as shown in the table below:

Table 1. Classification of skills assessed in the field by the teacher.

Type	Skills assessed
Soft skills	• Confidence • Ability to take decisions • Voluntary arrangement help • Artistic and creative skills • Ability to interact with others • Punctuality
Hard skills	• Cognitive engineering skills • Results practical engineering expected • Ability to implement theoretical knowledge acquired • Ability to use technology • Written and oral communication skills

RESULTS AND DISCUSION

The SCSE-2013 was held in November 2013 in the rural community of La Yeguada, Veraguas, Panama, for three consecutive days. In this ludic activity, as in didactic teaching, engineering students were grouped according to their personal affinities into five teams, which were called: DEM, AMFE, TOPO, DESLI and GEOM, respectively.

At this point, it is necessary to note that engineering careers traditionally have been labelled as typically masculine careers, because most of the students enrolled were male [16]. When the Universidad Tecnologica de Panamá was founded in 1981, this was the pattern. However, in recent years, the enrolment of female students in this university has been increasing, reaching approximately 45% by 2014.

This was reflected in the distribution of the different teams; some of the teams consisted by students of a particular gender, not an equal gender distribution among the teams formed. That is, some teams consisted mostly of either male or female students. This seems to show that students of the same gender feel *more comfortable* working with other members of the same gender [17]. However, regardless of the teams formed, it was necessary to establish additional work committees to carry out the extra-class activity. That is, all previous activities were organised, planned and implemented by students under teacher supervision. These working committees were not necessarily composed of the same members of each of the five participating teams. As mentioned earlier, for the development of SCSE the students, by own choice, had to select a different working committee, i.e. logistics, supply and transportation, within which they were expected to perform all activities designated for that committee, so that the event was given as scheduled.

Once the students arrived at the SCSE venue, general instructions were given to participating teams on security issues, responsibilities and what was expected to be reach and achieved in terms of learning at the end of the school day-out.

Figure 1 shows a photographic sequence for the realisation of SCSE.

Figure 1: Civil engineering students participating at SCSE-2013. From left to right: a) camping distribution; b) one of the five participating teams; c) oral presentation of academic poster; d) physico-chemical properties measuring of volcanic lake; and e) sample petrographic characterisation.

During the SCSE, the soft and hard skills were assessed by the teacher in the following categories: hiking, recreation and sports, voluntary cooperation and support; academic poster presentation, technical article and verbal support to the project.

Also in the field, five academic practices were developed, namely: 1) petrographic characterisation of rocks samples; 2) slope and trees declivities determination; 3) determination of flows in surface water sources and hot springs; 4) recognition of soils; and 5) geographical orientation in open field. The above described activities should be performed by the teams according to the implements which were available at that time; i.e. trying to *survive* the activity.

This aimed to identify teams that were advancing towards reaching the goals, i.e. they advanced in the student competition for survival in the field. On the other hand, those teams, which were lagging behind, received feedback, so that they could also achieve the goals of learning paths. The results were weighted for each of the five teams and are presented in Figure 2.

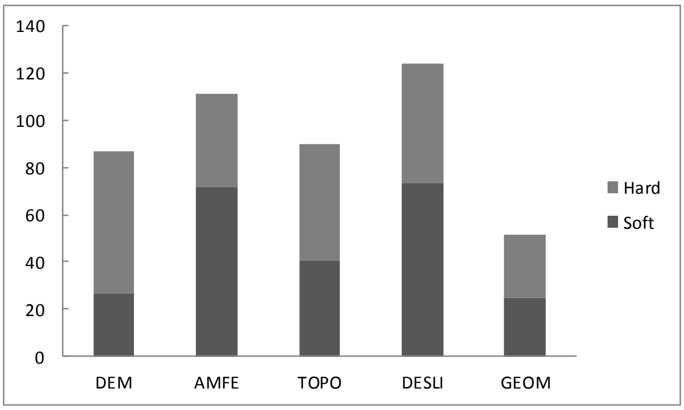

Figure 2: Soft and hard skills' final weights for team of student participants at the SCSE.

Of the groups participating in the SCSE, the DEM team was the one with the greatest levels of hard skills, while the AMFE team had the highest levels of soft skills. However, the DESLI group was weighted towards higher levels of technical and non-technical skills both in and out of class.

This shows that some students have good intellectual capital [18], i.e. cognitively they are good with excellent technical skills, but have weak non-technical skills and few co-operation skills. This goes against what is indicated in the literature [19]. Authors are of the opinion that today, due to the competitive and global marketplace, there are demands that future engineers possess *soft skills* in addition to the technical skills of the profession, and that they are able to undertake projects with human, material and financial resources.

That is, there must be a *balance* between the technical and non-technical skills [20], as evidenced by the TOPO team; which are necessary to successfully enter and take professional sustainability in the labour market; for this reason, both kind of skills should be encouraged and worked out in engineering education [12].

CONCLUSIONS

Upon completion this study, the author concluded the following:

- In terms of engineering education curriculum planning, it is necessary that students have an active role in their learning.

- It may show that some students have good intellectual capital, i.e. cognitively are good with excellent technical skills, but have weak non-technical skills and few co-operation skills. This goes against what is desired today of engineering students in the labour market; therefore, it is necessary to work on new teaching approaches in this regard.

- The SCSE is presented as a ludic activity for effective didactic strategies to identify and understand competences acquired by students.

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