Implementation Issues of Student-Centered Learning based Engineering Education in Developing Countries Universities

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***Abstract*— Student-Centered Learning is one of the most popular and promising instruction approaches as it is supposed to enhance the active role of students on Engineering Education. Although there are multiple advantages of employing it, there are also multiple implementation issues that have been identified by previous works. Unfortunately, the focus of those works was mostly referring to developed countries context. However, due to differences technological and teaching support resources, as curricula structure, individual academic regulations and even culture, some dissimilarities are induced on the actual issues in developing countries. In this work, we explore the corresponding matters of Student-Centered Learning over Engineering Education in the context of a fraction of developing countries. An analysis of issues' similarities and differences suggests that, despite the common difficulties, developing countries may be more distant from real SCL implementation as they seem to have more complex problems than developed economies.**

Keywords—Student-Centered Learning; Engineering Education; Developing Countries

I. INTRODUCTION

Engineering Education (EE) has seen many changes over history answering to requirements that society presented through the years. As an example, the way engineering was instructed in the 1940s is by far very different to the modern approach because in such years the emphasis was pointed to practical and non-professional skills [1]. These requirements are product of specific contexts or scenarios that involve socio-political and economic aspects. Universities, as main Higher Education Institutions (HEI) and primary actors in EE, were and are responsible to implement the required changes to face the requirements.

The current information age marks another context that HEI must consider. As information can be found easily on the Internet, students are vastly exposed to an incredible amount of data, however, by only finding information students don't learn. Thus, the explicit need for training learners; students that are capable of learning autonomously even when there isn't a formal guide. At the same time, given that globalization is omnipresent, engineering students have to be prepared to work in teams, with plenty diversity, and address global challenges [2].

Student-Centered Learning (SCL) and Learner-Centered Teaching (LCT) are approaches to enhance the learning process of students letting them learn actively. The main premise in these approaches is to make the student define his or her learning process. Then, students can establish their learning goals and the ways they will pursue them [3]. The advantages that these approaches present allow higher education, and therefore EE, to address the main challenge: training learners for a globalized and technological environment.

Unfortunately, implementing SCL is not easy as it represents change in general. In one hand, there are challenges involving students and instructors. On the other, challenges related to resources and infrastructure of institutions. Both perspectives have been studied before [4]–[7], however, it is not entirely clear if the analyzed challenges and issues are the same in every country. Specifically, the question of interest is if developing countries experience the same difficulties with the same intensity at the time of implementing SCL. Hence the aim of this work: to study the challenges of implementing SCL in developing countries and contrast those to the already documented in the literature.

This paper is organized as follows: section II defines what Student-Centered Learning is, states what relationship to Engineering Education can be found and lists some challenges of the approach. Later, section III explores the Developing Countries framework to stablish respective implementation challenges and presents a discussion comparing context of developing and developed countries. Finally, section IV exposes the conclusions of this work.

II. STUDENT-CENTERED LEARNING (SCL)

To define what SCL is, we focus first on the aspects that were identified on a previous work. Following the discussion on [4], Higher Education Institutions (HEI) have traditionally relied on the instructor-centered approach which can be reflected on five areas: (1) balance of power, (2) function of content, (3) role of the teacher, (4) responsibility of learning, and (5) purpose and

processes of evaluation. The fact that the instructor is the center in all these areas may produce unsatisfying results as students do not become successful learners or flexible enough to respond to highly dynamic modern work environments. Therefore, students, teachers and employers are not satisfied: students, because they feel frustrated, less motivated and without confidence; teachers, because they see students failing at achieving the stablished course goals; and employers, because students can't answer to professional requirements. Although this dissatisfaction may be considered a systemic issue that involves the entire higher education ecosystem, it cannot be denied that the way instructors teach influences greatly.

The previous difficulties in Higher Education started the discussion on the need of making students more active in their learning process. This introduced active learning, an approach that changes the role of: (1) students, which are assumed to be responsible of learning decisions, and (2) professors, that must use formal training design elements focused on encouraging individual cognitive, motivational and emotional processes [8]. It follows then, that active learning makes teaching centered in students.

Student-Centered Learning is an approach intimately related to Student-Centered Instruction (SCI) [3], and Learner-Centered Teaching [9]. The aim of this approach is to shift the role of students, from passive to active, making them: responsible for learning goals or achievements, players in the course planning process, and active during the instruction time. Simultaneously, the shift also applies to teachers or instructors, from merely speakers to guiders, turning them into facilitators that accompany the learning process of students.

Given the nature of SCL, learning experience can be tailored to students' capabilities. Thus, strategies that are applied in courses should consider appropriate levels of difficulty and different students' style of learning. Three strategies might be thought when it comes to SCL [5], [10]:

- Problem-based Learning – When students address small-scale problems in short periods of time reflecting what they have learned.
- Project-led Learning – When students address a large-scale and complex problem by means of a realistic project in a relatively large period.
- Case-based learning – When students address a scenario which reflects real aspects of the profession and the problems what may be found.

These strategies are complementary as an appropriate proposed project could be composed of many small problems, and a specific case may require the formulation of such project. Moreover, because of the complexity of problems, these can also be suitable to work on teams, enhancing cooperative learning. Other approaches to SCL are mentioned in [11].

Employment of technological tools to address cooperation learning is not unusual, being an LMS (Learning Management System) or even social apps, these tools have the purpose of allowing communication among groups of students. For example, in [12] authors contrast the usage of WeChat and Moodle on the creation and utilization of student-centered group discussions. Their findings point to Moodle as the better collaborative learning tool, but the study highlights the easiness of WeChat.

Implementation of SCL requires instructors to be creative on the processes of change; this does not always involve using technology but merging or blend practices. For example, in [5] authors report the process of implementing SCL in an large engineering course having two types of classes, lectured and practical. From the beginning, the class used active student participation to define how the course in general will be carried out. These promoted active learning and participation towards the goal of "I do it, I learn it". During the course, students, organized in teams, had to demonstrate project management abilities, scheduling and progress reporting. Self-evaluation and assessment of peers were implemented and technological tools (Blackboard LMS and email) were used. Among the remarked authors' conclusions is the high enthusiasm and commitment that students had to the project, and, at the same time, the low interest regarding to the lecturing part.

A. Engineering Education

Engineers usually require computers to work, whether they are using software to design or simulate, their jobs are intrinsic to computer-based technologies. The fact that these technologies are rapidly evolving makes clear the need for training or instructing computer and adaptability skills. Hence, engineering education considers, with frequency, computer-based courses engineering programs.

SCL has been applied successfully to engineering classes, particularly those with large audience and different learning styles [5]. This is of particular interest to Engineering Education as classes of engineering are not usually considered environments that promote participation and persistence as Gaskins et al. mentioned in [13].

An aspect of interest that is usually included in engineering education is the "learning by doing" approach. This approach requires students to experience and learning by doing so [3]. However, by simply experiencing, students cannot be immerse in an active learning environment [8]. Therefore, "Learning by doing" must be an element of a better formally structured active learning led student-centered approach. Activity-Based Approach [11] has been proposed to include the "hands-on" experiments and activities in an active learning framework; the approach was successfully implemented in two courses: "Digital Signal Processing" and "Mobile Communication".

The impact of using SCL in STEM (Science, Technology, Engineering, and Mathematics) has been previously explored. [14] develops an extensive meta-analysis of 225 reported studies concluding on the positive impact of student-centered teaching in science, engineering and mathematics. [15] studies beliefs and practices of employing Student-Centered Learning strategies in classrooms concluding in promising findings of the shift towards Student-Centered Teaching practices. In general, the usage of SCL in EE is encouraged, however, it doesn't lack of challenges.

B. Challenges

Using SCL involves a change of mind of instructors and students. But at the same time, it supposes a change of policies in the administrative framework of the HEI. Both aspects, educational and administrative, can be thought as challenges to address to achieve an appropriate SCL approach.

Focusing first on the curriculum challenge. As was noted before, SCL oriented programs require an appropriate academic restructuration to consider appropriate course contents that can be negotiated later with students. Moreover, there is also a need for conceptualize, design or select more suitable options for evaluation. As a matter of fact, by only having the curriculum changed, the evaluation might focus on wrong aspects of formation and therefore, it may generate frustrations and helplessness attitudes. SCL requires the designed curricula to prioritize students over contents, however, not every institution has a specialized staff that can work on this.

Frameworks that allow the design of the environment to enhance Student-Centered Learning have been previously proposed [10], [16]. Nevertheless, these and others SCL works or advances may not reach the communities that have interest in them. Sadly, [17] reported the low diffusion rate that an Engineering Education innovation suffered and, therefore, the low expectance of an innovation to reach an application scenario. But even when innovation reaches instructors, this does not ensure that it will be applied. Hence another challenge: supporting faculty in the SCL incursion.

Faculty might be interested in applying SCL strategies but this does not ensures they are actively trying to include them on their courses [17]. As a matter of fact, finding resistance among students or teachers is very common because of the way we had being trained: teacher-centered; Weimer [4] calls this phenomenon: the resistance. There is an open topic about faculty members who don't want to shift to SCL even when the HEI guidelines specify to do so; in general, it can be said that faculty and students must believe in SCL to achieve good results.

On the other hand, Engineering Education based on SCL requires tools to make possible students perform certain activities. These tools should fulfill a premise: allow students to engage and learn by doing. In consequence, the tools must let build an Activity-Based Approach to enhance learning processes. However, the required devices might be expensive to afford or to keep in good conditions given large number of students. This challenge involves infrastructure resources that must be met to enable appropriate implementation of SCL.

Regarding to specific challenges, by recalling [12], Moodle was found to be the best option to encourage cooperative learning virtually. Still, as any specialized software requires training, an important challenge makes present: instruction over technological tools. Despite being a student or an instructor, the person who use the technological tool must be trained to exploit advantages of the software/hardware. This process, although might seem simple, should involves a training stage for students and instructors. It must be noted here too, that with the vast amount of available technological tools in the market, instructors must be aware of all pertinent to keep improving and updating.

An interesting remark of [13], a work which is focused on using Challenge-Based Learning on Basic Electric Circuits course, is that the way student-centered learning approaches are measured should change. Courses that rely on SCL strategies to teach but use traditional tools to evaluate may have been committing an error of concept at measuring student outcomes. This is because the way students should be evaluated must be related to real scenario problems instead of traditional exams [13]. Exams, as a way of measuring learning, are not very recommended when evaluating students learning goals over SCL approaches.

Recalling [5], implementation of the methodology might be feasible to courses where the Project-Based Learning approach is appropriate. Success of the proposal depends of the instructors and students' commitment. Therefore, beliefs of instructors towards SCL must be positive and the attitudes of students must show the engagement to their learning goals. This reveals once again the importance of supporting learners and teachers through the implementation of SCL.

Given that constructs of SCL are intrinsic to constructivist learning theory and can be identified as: engagement, scaffolding and authentic audience [10]. These are supposed to be encouraged and address by instructors and the learning environment to apply SCL appropriately. However, if any of the SCL aspects is not accomplished, it turns more difficult to reach the desired results.

Detected difficulties and challenges are summarized in Table 1. Yet, there might be more than the listed ones, but these are thought to be universal given the previous analysis.

TABLE I. CHALLENGES IN SCL

Character	***Challenge***	***Involves***
Administrative & Educational	Curriculum adaptation or restructuration	Teachers and education managers
Educational	Assume responsibility of learning goals	Students
Administrative & Educational	Lack of technological tools knowledge	Teachers and students
Educational	Beliefs' shift regarding SCL	Teachers and students
Administrative	Tools and resources to create appropriate infrastructure for SCL environments	HEI administrative
Administrative & Educational	Supporting the shift of mind of students and instructors towards SCL	Teachers, students, education managers, HEI administrative

III. THE DEVELOPING COUNTRIES FRAMEWORK

Although "Developing countries" is not a concept of the United Nations, the World Bank specifies a list where countries with less economic development are listed in [18]. Some common problems of these countries are:

- Lack of sustainable development
- Low economic development
- Corruption

- Lack of technological access

Academic profession, which involves teaching and researching mainly, in Developing Countries suffers from the mentioned problems. In [19], Altbach presents an extensive review of the academic profession issues in developing countries is presented. In general, the problems Altbach mentions are corruption, low remuneration, inadequate working conditions, lack of academic freedom, bureaucracy and politics, institutional environment. Sadly, developing countries don't have appropriate teaching-learning and research environments that can match to Developed Countries universities. From the structure of professorship, mostly part-time personal, to the lack of formal training and competence in teaching or research of full-time academics, universities of Developing Countries are underdeveloped [19].

Overall, there are certain faculty development programs that have been applied in developing countries successfully:

In Kenya, a country with a large population of refugee, a program of "Education in Emergencies" was implemented to address "educational needs of children and youth affected by conflict and crisis" [20]. The program curriculum included SCL approach elements, however, some issues were found at the beginning when SCL couldn't be included on the courses due to the "work overload", according to Kenyan professors, and the lack of "reading culture", according to the Kenyan faculty. Besides that, susceptibility and fear of losing respect due to the shift of instructors' roles was present. Fortunately, issues were solved, and the program went ahead.

Thomas and Salema [21] describe that recent increases in the number of students and HEI in Sub-Saharan Africa has turned classrooms and professorship inadequate. The former due to the insufficient number of students that can fit in a room, and the latter due to the insufficient number of people with adequate education degrees. The work reported by Thomas and Salema focused on the insufficiency of appropriate staff to teach in Tanzania. Given that there aren't many people with the doctorate degree, which is required teach in Tanzania, HEI started to hire people with bachelor's or masters' degree. This caused issues in the quality of teaching because not all the hired staff had experience on teaching. To address these problems, a project to "build the research capacity of junior faculty" at the Mwenge Catholic University was performed [21]. The program focused on teaching through research, thus, research methods and teaching management tools were studied. The project got positive results as it allowed participants to realize of other ways to reach students and teach them.

In Mozambique, an approach to SCL using LMS was implemented in Eduardo Mondlane University in the course: "ICT in Environmental Education" [22]. The course was structured similarly to [5] in the way of using LMS to organize the course and monitor students activities. Moreover, because of the learning goals of the course, there was high emphasis to the development of Web 2.0 tools usage. SCL strategies were implemented with that objective, encourage students to discover and employ the tools by themselves. Although most of the students were satisfied with the SCL approach, some of them presented some resistance to being active learners. An important remark that can be seen in the work is that many students didn't have an experience with technology, specifically with ICT (Information and Communication Technologies).

In Bolivia, approaches to SCL are focused in the Competencies Approach; a competency is defined as "complex knowledge" that the student must develop. Each course has an associated competency which can be generic, basic or specific. While generic competencies refer to generic skills, basic competencies denote those abilities that students must primarily develop. Additionally, specific competencies focus on professionalizing skills. SCL strategies are thought to be blended with traditional lecturing in every course with priorities defined by professors; professors can choose to focus entirely or partially on SCL. Therefore, a conceptual similitude to [5] can be found. However, the number of part-time lecturers and generational issues of them is by far one of the main concerns.

Implementing SCL in Developing Countries is not an easy task. Their universities' context, socioeconomical and academic, is complex and unfortunately, does not always encourage new incursions on education. Challenges are identified and contrasted to the already listed in the next section.

A. Challenges of implementation

Recalling the challenges in Table 1, some of them are clearly present in Developing Countries:

- Curriculum adaptation or restructuration - [20], [21] showed that there isn't a program which emphasizes directed to SCL.
- Assume responsibility of learning goals - [22] mentions the resistance of active learner shift.
- Lack of technological tools knowledge - [22] focused on the development of web 2.0 tools knowledge. In developed countries, some of these tools, e.g. Facebook and email accounts, are native to students.
- Beliefs' shift regarding SCL – In [20] faculty expressed concerns about losing respect of students. This idea may come from misunderstandings of what SCL means and, therefore, wrong beliefs of faculty regarding to the approach.
- Tools and resources to create appropriate infrastructure for SCL environments – Being LMS an essential tool in nowadays courses, even those which are based in SCL, an appropriate infrastructure requires technological resources. Unfortunately, Developing Countries usually lack of appropriate technology and weak user-training related to virtual learning environments [23]. On the other hand, because of bureaucracy and corruption, universities in Developing Countries may find obstacles when trying to set up the infrastructure.
- Supporting the shift of mind of students and instructors towards SCL – The reason of the help reported in [21] was related to the lack of staff trained in Education. It follows that if there is insufficient trained staff, there is no chance to support the shift of mind which requires of staff appropriately trained in SCL.

Furthermore, specific challenges related to problems of Developing Countries are presented next:

- Lack of full-time staff – Students cannot rely on permanent guide. Also, professors cannot dedicate their full attention to their students because of extra activities they do to compensate the low remuneration. Full-time professors lack of time to improve the teaching process due to "work overload".
- Lack of trained instructors – As was stated, many Developing Countries are forced to hire bachelor's degree instructors. Although this is not necessarily wrong, not every hired instructor has enough experience to teach or research. On the other hand, as SCL requires guidance from the instructors rather than direct instruction, instructors need experience on the specific course topic.
- Lack of tools to focus on Engineering Education – Activity-Based Approach implies that students should learn while practicing. However, to practice engineering, educational devices and simulators are needed. Unfortunately, because of bureaucracy and politics, requests of educators to managers may experience delays other issues.
- Lack of technological access – Because of the globalized world, information can be accessed easily, but educational devices and platforms still need to be imported from Developed Countries. This shouldn't be a problem, but multiple issues can be found, e.g. high fees for importing (despite being educational devices), corruption, long shipping delays.

IV. Conclusions

Student-Centered Learning is a promising teaching-learning paradigm that emphasizes the work done by students and changes the role of teachers to make them guides of the learning process. Engineering Education can be greatly improved if SCL is used appropriately as it can encourage students to develop highly critical skills and cooperative skills.

Implementation of SCL is not easy to achieve as it represents a shift of mind in instructors, students' and even education managers. Challenges regarding to SCL implementation are vast and include four protagonists: students, teachers, education managers, and HEI's administrative. Developed Countries have turned their attention to SCL, as evidence suggests that improves education in general, and have started to research on good practices, effects, etc. However, Developing Countries have mainly stated the importance of SCL and are partially unable to develop SCL based programs unless collaboration from Developed Countries is done.

Developing Countries per se experience specific difficulties that make hard the implementation of SCL at the same pace and level than Developed Countries. Given the exploration of challenges and issues, it is now possible to work towards approaching of the problem. However, it should not be dismissed the possibility of addressing the issues by means of collaboration programs with universities of the Developed Countries.

Acknowledgment

The authors would like to thank Universidad Católica Boliviana "San Pablo" for supporting this work.

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