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A Co-Teaching model between Egyptian scientists and Expats for a Third-Year design courses in Sustainable Design Engineering Program

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Abstract

The present paper highlights a co-teaching model between Egyptian scholars and expats for a third-year design courses in the Sustainable Design Engineering program at the University of Prince Edward Island in Canada and its Cairo branch campus in Egypt. A team-based industry partner project was initiated, students were involved in a project was conducted. The students worked on the design project under the supervision of both the Egyptian and the Canadian faculty and they succeeded to propose a design solution aided by the manufacturing of a machine prototype. The co-teaching model was assessed with reference to the ability to tackle the twelve graduate attributes needed by an engineering graduate. The assessment was conducted via a survey sent to the industry partner. This model showed an overall very good ability to tackle most of the graduate attributes with room for improvement in two graduate attributes in the next design clinic.

Keywords: Higher Education, Co-teaching techniques, Engineering Education, Inclusiveness in Engineering.

1. Introduction

1.1. Egypt Vision 2030

In 2016, Egypt had set an optimistic vision for the year 2030, the vison aims to achieve a competitive and diversified economy while maintaining a good balance between the three sustainability dimensions: Economic, environmental, and social. Scientific research and quality education have been identified in the ten pillars of the Egyptian sustainable development strategy and its three sustainability dimensions. For example, the third pillar that belongs to the economic dimension aims to develop a creative and society that produces science, technology, and knowledge. Similarly, the seventh pillar encompassed within the social dimension of sustainability emphasizes the need for high-quality education within an efficient, sustainable, and flexible institutional framework. One of the programs that have been identified to achieve economic development by 2030 is the development of the new capital with its knowledge city that encompasses universities and centers of research, science, innovation, and entrepreneurship. In the same line, One of the key performance indicators for knowledge innovation, scientific research in 2030 that the government has set is to improve the quality of scientific research institutions by 55.5%. In the same line, a key performance indicator for higher education in 2030 is the number of higher education institutions which was aimed to increase by 50%. The targets are planned to be achieved by encouraging partnerships with quality education institutions and establishing international branch campuses in the new capital (Arab Development Portal, 2021) . An international branch campus is defined as an educational institute in which learners are located in a country different from those awarding the degree (Huisman, 2012). In response to this strategy, the private sector has launched several internal branch campuses in Egypt. The first one was the University of Prince Edward Island that opened its doors to national and international students in September 2018 and currently offers four different programs: Sustainable Design

Engineering, Mathematical and Computational Sciences, Arts and Business.

1.2. Co-teaching model in international Branch Campus

In an international branch campus, a co-teaching model between instructors from the mother university and the host university is adopted to ensure that the students acquire the same learning experience on both campuses and that instructors are expanding into other content areas and educational settings (Scantlebury, 2010). In the Sustainable Design Engineering program (SDE), the third-year design courses "Project-Based Pro Practice I" and "Project-Based Pro Practice II" constitute 216 from a total of 2,292 accreditation units required in the program, representing approximately 10% of the total required credit hours in the SDE. The two courses collectively simulate a professional engineer's practice and encourage students to work in teams to deliver design solutions to industrial clients by developing detailed project proposals, conceptual designs, and operational prototypes within an engineering profession's ethical and safety considerations.

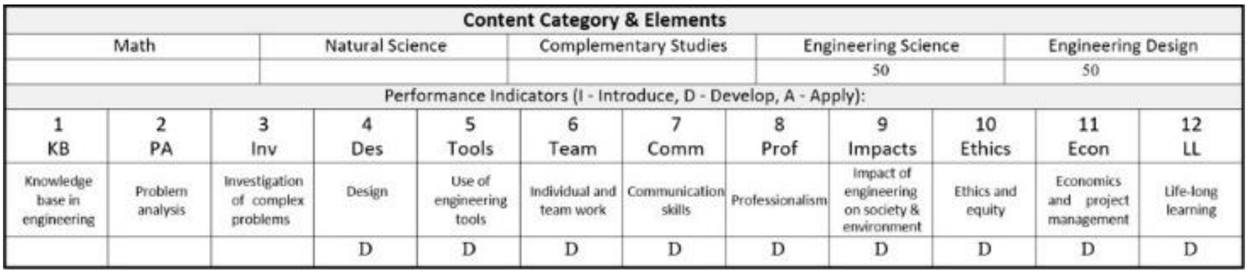
In Cairo, both design courses were taught using a co-teaching model between experienced instructors from Canada and Egypt. The courses were delivered over a full academic year from September 2020 to April 2021 through a twelve-contact hour of weekly lectures and laboratories. Due to COVID restrictions, approximately 16% of the laboratory time and 25% of the lecture time were delivered online. The online classes were allocated to the instructor from Canada, whereas the physical laboratory and class time were allocated to the instructor from Egypt.

1.4. Aim and Methodology

This paper will tackle a design course taught to third year students enrolled in sustainable design engineering program. The teaching model will be discussed, brief description of the project and the outcome of the student's work will also be discussed. Lastly the overall performance of the students will be assessed to validate the effectiveness of this model. The assessment will be done with reference to the 12 graduate attributes assigned by the Canadian engineering accreditation board (CEAB) also known as Engineers Canada.

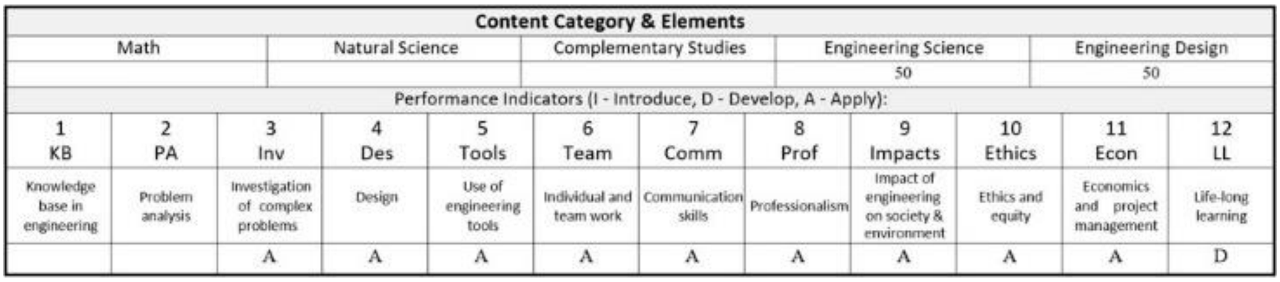
The Canadian Engineering Accreditation Board (CEAB) has set 12 graduate attributes that the students must adopt, experience and master upon graduation. Table 1 lists the 12 graduate attributes (Canadaian Engineering Accrediatation Board, 2021), and the letter "D" stands for "Develop". Accordingly, the major target is to expose students to developing the listed graduate attributes in the first semester of the academic year. For instance, the course at hand possesses nine graduate attributes that should be developed during the semester. On the other hand, the course in the second semester possesses ten graduate attributes, Table 2, with nine attributes being an "A" which stands for "Apply" and a single "D" for the life-long learning graduate attribute. Precisely, in the second semester the major focus is on applying what the students have developed in the first semester. Both Tables 1 and 2 summarize how the students moved within the frame of the graduate attributes throughout semesters 1 and 2 respectively to solve the problem based upon scientific and well-organized

Table 1: Graduate attributes for the first semester of the academic year.



Content Category & Elements											
Math		Natural Science		Complementary Studies			Engineering Science		Engineering Design		
							50		50		
Performance Indicators (I - Introduce, D - Develop, A - Apply):											
1 KB	2 PA	3 Inv	4 Des	5 Tools	6 Team	7 Comm	8 Prof	9 Impacts	10 Ethics	11 Econ	12 LL
Knowledge base in engineering	Problem analysis	Investigation of complex problems	Design	Use of engineering tools	Individual and team work	Communication skills	Professionalism	Impact of engineering on society & environment	Ethics and equity	Economics and project management	Life-long learning
			D	D	D	D	D	D	D	D	D

Table 2: Graduate attributes for the second semester of the academic year.



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Knowledge base in engineering	Problem analysis	Investigation of complex problems	Design	Use of engineering tools	Individual and team work	Communication skills	Professionalism	Impact of engineering on society & environment	Ethics and equity	Economics and project management	Life-long learning
		A	A	A	A	A	A	A	A	A	D

2. Teaching Approach

2.1. Project-Based Professional Practice (description and structure)

In a design-based program, students are expected to continuously apply the design process in all their study years. This is ensured by introducing the concept of design clinics, the design clinic is a course taken by the students every year. This course is a yearlong course were the students have to execute a project, this project can either be in house project in their first- and second-year clinics or in collaboration with industry partners in their third and fourth year. The third- and fourth-year design clinics are namely called “Project-Based Professional practice. The project time span is one academic year in the courses “Project-Based Professional Practice -I” and “Project-Based Professional Practice -II. A total of ten students are in year 3 for the fall 2020 and winter 2021 semesters. The students were divided into two groups, with five students per group. The students visited the factory and saw the entire screening process, where they met the engineers, documented data, took photos, and had several discussions with the chief engineer. In the fall of 2020 semester, regular meetings were conducted with the industry partner to see the progress towards solving the problem. Contrarily, in the winter 2021 semester, condensed biweekly meetings were conducted with the industry partner in addition to on-demand virtual ZOOM meetings. It is important to mention that third year students were well educated concerning the engineering design process, which was intensely covered in their second year of the sustainable design engineering program. Parallel to the meetings mentioned earlier, regular class sessions were conducted in addition to a weekly common session with the Canadian coteaching faculty. Both groups successfully identified the clint’s need and went through the research, ideation, conceptual design, and preliminary design phases during the fall 2020 semester. More specifically, both groups proposed different solutions where the industry partner encouraged both groups to go ahead with the remaining engineering design phases.

2.2. Problem description

The course project is introduced by one of the largest iron and steel making companies in the middle east and the north African regions. The company possesses three gigantic steel manufacturing plants in Egypt. The company started its business by producing long steel bars used in the civil infrastructure and construction industry. In the year 2000, the company started manufacturing steel sheets within different thicknesses. Steel sheets are widely used in the automotive industry and industries related to household manufacturing, such as refrigerators, ovens, washing machines…etc. The present production volume reached more than 7.5 million tons of steel per year. The company imports raw iron oxide pellets from various suppliers in various countries such as Brazil, Russia, and China. The imported iron oxide pellets are initially introduced in a screening facility, huge screening machine, that admits 4 mm to 20 mm diameter spectrum sizes. Precisely, less than 4 mm and larger than 20 mm pellets are discarded by the enormous screening facility. Figure 1 shows a sample of the iron oxide imported pellets. The normal efficiency of the screening facility is 80%, as specified by the Italian producer of the screening facility. By the end of 2019, a noticeable decrease in the screening efficiency occurred, resulting in 60% operating efficiency. Figure 2 shows the huge screening facility, which is approximately a four-story building high, along with the main conveyor belt that transfers the iron oxide pellets to the feeding system of the screening facility. Figure 3 shows the inside of the screening facility where an upper deck holds numerous polyurethane tiles with a large aperture size and the lower deck holds numerous tiles with a smaller aperture size. The upper deck is used to admit 20 mm and below pellets diameter sizes, whereas the second finer meshed deck rejects pellets with less than 4 mm diameter pellets, as shown in Figure 4. The company contacted the Italian manufacturer of the screening machine concerning the loss in screening efficiency. The Italian manufacturer performed test studies at their facility in Italy, and their calculated efficiency was 82%. At this time, the company contacted the industry partnership team at UPEI Cairo campus to work with its students on finding and engineering solution to the efficiency problem.

Fig.1: Sample of iron oxide imported pellets.

Fig. 2: The screening facility at the steel factory.

Fig. 3: The screening facility with upper deck holding larger aperture polyurethane tiles and lower deck polyurethane tiles with smaller aperture.

Fig. 4: Larger upper deck polyurethane tile with large aperture and lower deck polyurethane tiles with smaller aperture.

2.3. Student's Work and Proposed design

The two student's groups filtered the conceptual design phase and chose a single solution per group within the preliminary design phase. The first group suggested the concept of wet screening, where the iron oxide pellets are sprinkled via high-pressure water sprinkler nozzles to remove all the dust. It is crucial to mention that the existence of dust results in various very expensive clogging problems that could halt the entire plant throughout the subsequent manufacturing processes of the iron oxide pellets. The only drawback of this solution is the need to implement a heating facility, so the washed pellets are dried well and ready for the subsequent direct reduction process. Figure 5 shows a photo of the wet screening, which is only found in a single iron and steel-making factory across the globe, namely, in the US.

The second group suggested implementing a static plate above the upper deck. Precisely, the static upper plate shall possess various rectangular apertures to evenly distribute the impact load of the iron pellets over the upper deck and hence increasing the screening efficiency. Figures 6(a) and 6(b) show schematics of the proposed static plate solution. Upon finishing the preliminary design phase, both groups started the detailed design phase, followed by building and testing a prototype of the screening facility. Both groups built a prototype with a scale ratio of 1:75. On the other hand, Figuers 7(a) and 7(b) show the prototype of the second group that adopted the rectangular static plate with various rectangular apertures to distribute the impact on the upper deck as evenly as possible.

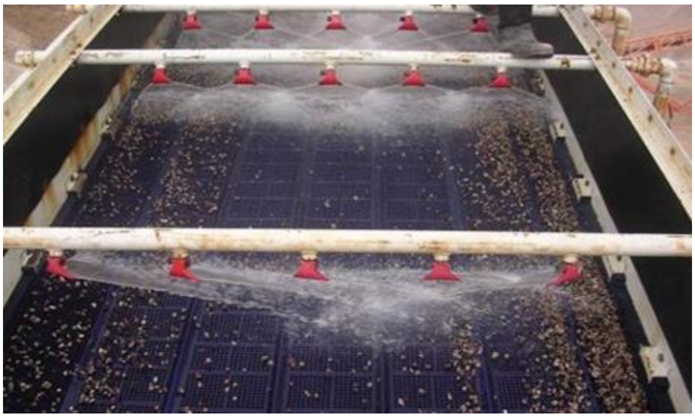

Fig. 5: Wet screening of the iron oxide pellets to remove dust.

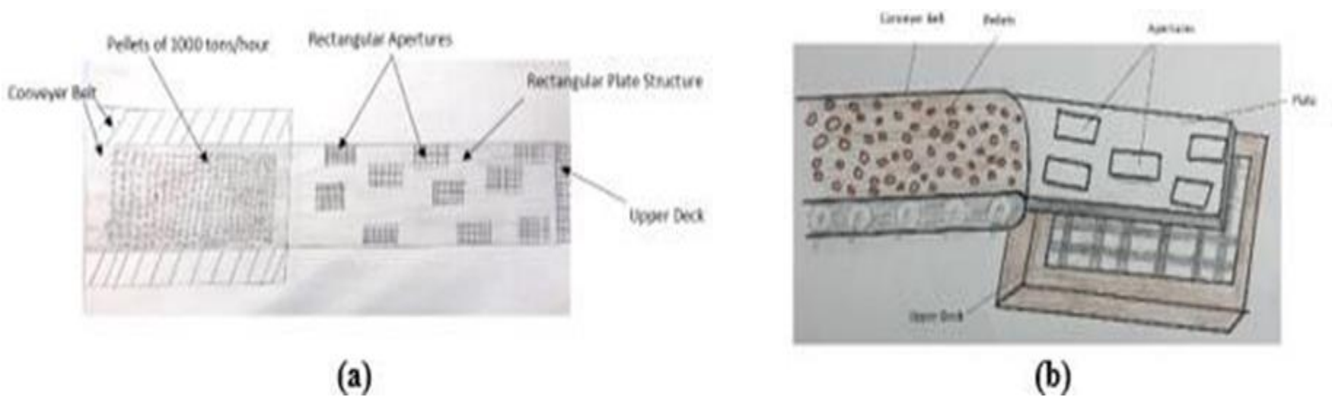

Fig. 6: Static plate solution with random rectangular apertures to reduce the impact of the iron pellets on the upper deck which is usually torn apart within the vicinity of the impact region.

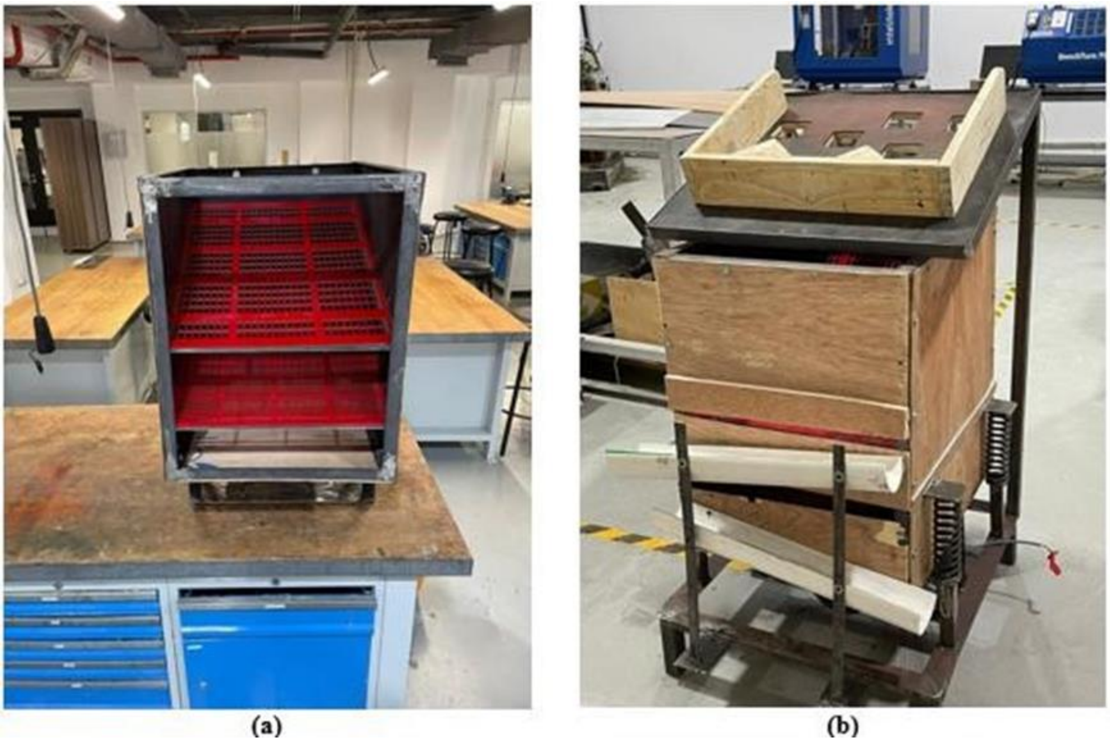

Fig. 7: The prototype of the second group showing (a) the inside decks holding the large aperture tiles in the upper deck and the smaller aperture tiles in the lower deck in addition to (b) the installation of the rectangular static plate with small rectangular apertures.

The test results of both groups showed a measured efficiency of approximately 61.5%, which is very close to the efficiency measured by the full-sized screening facility at the company of 63%, giving a 2.38% error between the prototype and the real screening facility. This gave confidence in the outcomes of the prototypes; however, the outcomes did not explain the reason behind the drop from 80% to 60% efficiency. Both groups started to take various random samples of the iron pellets and measure the diameters of the iron pellets. Five samples were gathered where each sample consists of 50 iron pellets. Measurements were input to MS Excel for all samples, and an average diameter was computed. The average diameter was 24 mm for more than 30% of the total gathered samples. This explains why the efficiency of the screening facility dropped from 80% to 60%. The main problem is with the Brazilian supplier of the iron oxide pellets, where the computed average diameter shows that something has gone wrong with the Brazilian supplier's quality control tolerances. This also explains the 80% efficiency scored by the Italian manufacturer of the screening machine where they used a proper source or supplier of the iron oxide pellets. The two groups provided two recommendations to the steel, namely, contact the Brazilian supplier to calibrate their iron oxide diameters and/or change the supplier

3. Results of the co-teaching model

The success of the co-teaching model is evaluated by the ability to tackle all graduate attributes and prepare the students for the professional practice. The evaluation of this is tackled through a survey sent to the industry partner after the submission of the functional prototype. The industry partner then evaluates the degree of which the students fulfil the graduate attributes and assess their overall performance.

The results indicate that the students demonstrated a very good level in deploying most of the graduate attributes. The result also shows that some of the attributes were deployed in an excellent way, while only two attributes were implemented with average level. These results are demonstrated in table 3 and figure 8. From these results it is clear that the co-teaching model showed functionality and succeeded in building the required skills in the students preparing them to start their professional practice. The industry partner feedback also showed a potential in further development of two graduate attributes which are design and Economics and project management, taking them from the average level to an excellent rating in the student's fourth year of study.

Table 3: industry partner opinion on the level of performance of students in relation to engineering graduate attribute.

Graduate Attribute	Level of student performance
Communication skills	Very Good
Individual and teamwork	Very Good
Design	Average
Use of Engineering tools	Very Good
Economics and project management	Average
Professionalism	Very Good
Impact of engineering on society and environment	Very Good
Ethics and equity	Excellent

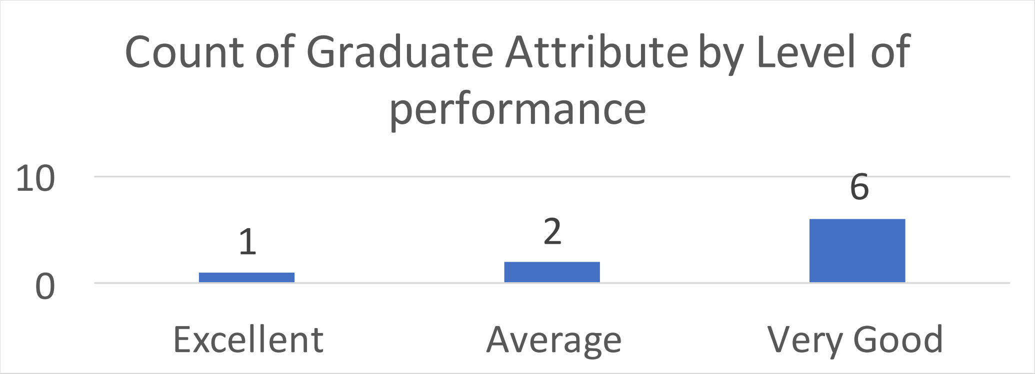

Fig. 8: industry partneropinion on the level of performance of students in relation to engineering graduate attribute.

4. Conclusion

A coteaching model between both Egyptian and Canadian faculty was used in delivering the third-year design course in the sustainable design engineering program offered by University of Prone Edward's Island (UPEI) at Cairo campus. The engineering program adapted a design-based delivery, where the a major design project or several design projects are presented to the students for them to design a solution. In the third year Project-Based Professional Practice -I" and "Project-Based Professional Practice -II a project from a major steel manufacturing company was given to the students to develop a solution. Frequent meeting meetings between both the students and the industry partner were conducted to avoid misconceptions and ease in exchanging the information between both parties. The teamwork provided by both the Egyptian and the Canadian faculty thoroughly aided in keeping the correct path to the solution via the feedback from one design phase to the following phase and generally through the entire phases of the design process. The success of the model was measured by linking the output of the courses to the twelve graduate attributes intended. This was assessed via a survey given to the industry partner. The coteaching model provided a very good delivery of most of the graduate attributes, the feedback obtained by the industry partner also showed areas of improvement in both design and economics and project management to be tackled in the next design course.

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