*Maatouk Khoukhi*

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**Assessment of General Engineering Courses in Architectural Engineering Program in the UAE University and Recommendation Actions for Improvement**

**Maatouk Khoukhi**

*College of Engineering, United Arab Emirates University, Al Ain, UAE, mkhoukhi@uaeu.ac.ae*

**Abstract**

*The current study examined the Architectural Engineering (AE) students at College of Engineering (CE) at United Arab Emirates University (UAEU) learning outcomes through assessing three main engineering requirement courses. The assessment is based on the direct method which consists on the achievement of the students and their capability to demonstrate mastery through actual work or work products such as exams and assignments. The courses learning outcomes (CLOs) for each course for the AE program have been analyzed in term of level of achievement and compared with the overall achievements of all students enrolled in the same courses at the CE. This assessment has been carried out for three continuous semester fall 2019, spring 2020, and fall 2020. Indeed, some deficiencies in term of CLOs achievement which has been set below 70% are recorded and remedial actions have been provided for improvement. The second part of this study consist on the comparison of the attainment level of the CLOs of one selected course between two consecutives semester fall 2019 and spring 2020. Indeed, this period was characterized by the drastic change in the teaching method moving from traditional way of face to face interaction with student to online teaching. The engineering general course of Ethics (GENG215) has been assessed in term of comparison of CLOs attainment between the two teaching methods. The CLO related to the design process using systematic design methods appears to be more affected with lower performance obtained during the online teaching period where both the students and instructors were not that prepared to tackle different situations, opportunities, and problems associated with the online scenario.*

**Keywords**

General engineering courses; Architectural Engineering Program; Course assessment; ABET

**1. Introduction**

Different college programs are assessing and monitoring students learning outcomes by implementing several assessment tools across multiple levels within their institutions (Banta, 2004). Two major methods of courses assessment are being used by academic institutions which are direct and indirect methods. Direct methods of courses assessment demonstrate mastery through exams and assignments for instance. Indirect measures, reflect opinions and are obtained from surveys and interviews (Price & Randall, 2008).

The United Arab Emirates University (UAEU) has 9 separate colleges, in addition to College of Graduate Studies and University College, hosting a comprehensive range of academic disciplines and departments (https://www.uaeu.ac.ae/en/colleges.shtml). The College of Engineering (CE) was inaugurated in 1980 and includes five academic departments that offer seven Bachelor degrees, namely Architectural Engineering, Chemical Engineering, Civil Engineering, Communication Engineering, Electrical Engineering, Mechanical Engineering, and Petroleum Engineering, all of which are recognized nationally by the Ministry of Higher Education and Scientific Research. In addition, all undergraduate programs in the CE are accredited by the Engineering Accreditation Commission of Accreditation Board for Engineering and Technology (ABET) (https://eng.uaeu.ac.ae/en/about/index.shtml). ABET is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology (https://www.abet.org/).

The Center for Excellence in Teaching & Learning (CETL) supports the UAEU’s strategic vision and mission by promoting emerging educational technologies and teaching pedagogies among faculty members and instructors. This center promotes discovery, reflection, and evidence based methods to research on effective teaching and student learning and assessing and measuring teaching effectiveness and efficiency as well. All courses taught at CE are subjected each semester to direct and indirect assessment.

The College of Engineering Requirement Courses (ERU) provide students with solid foundation in basic science, mathematics and general engineering fundamentals. The ERU manages and coordinates with the College of Science to offer all basic science courses (including mathematics, physics and chemistry courses) that are required to be taken by all students in the CE. Moreover, the unit offers the general fundamental engineering courses that are needed for all CE students including Engineering Ethics (GENG215), Engineering Thermodynamics (GENG220), and Engineering Economics (GENG315) (https://eng.uaeu.ac.ae/en/departments/eru/about.shtml).

As mentioned above this study will focus on the direct measures of learning which demonstrate a master of knowledge rather than an opinion about one’s ability. There are several methods of direct measurement as described by (Luce & Kirman, 2016) which include tests, papers, projects and presentations. This direct method administered through the whole semester will identify the increased knowledge gained by the students from the start to the end of the course (Pederson & White, 2011). Several researchers highlighted the importance to clarify what we want students to learn from the assignments and the build and design the assignments that will help them achieve those goals (Banta &Palomba, 2015; Suskie, 2009).

The target of this paper is to highlight the assessment of the GENG215, GENG220, and GENG315 taken by AE students and compare them with CE students and provide the recommendation actions for improvement during the last three semesters. The impact of online teaching students’ performance was also analyzed for GENG215 and the most affected CLO was highlighted.

**2. Methodology**

The target population for this study consists of undergraduate students in CE at UAEU. Three courses have been considered in this study which are college requirement courses taken by all students enrolled in the CE. The courses are Engineering Ethics with course code GENG 215, Engineering Thermodynamics with course code GENG 220, and Engineering Economics with course code GENG 315. The GENG 215 as a set of moral principles that relate to Engineering projects and designs. The course explores creative ways of reconciling conflicting moral claims. It outlines the responsibilities of engineers towards public safety and the environment, within economic constraints and governing laws. The GENG 220 deals with the basic thermo-physical properties of pure substances and gases with the introduction to the first law of thermodynamics, conservation of energy, and closed and open systems. The second law of thermodynamics and entropy are also introduced in this course. The GENG 315 is related to the basic concepts and principles of engineering economics. Familiarization of the different cost components, cost estimation techniques, cash flow analysis, time value of money, and measures of project performance. [https://eng.uaeu.ac.ae/en/departments/eru/courses.shtml].

Each CLO is analyzed and direct and indirect results are reported for each section taught for the considered courses. The attainment target is reached for 70% of enrolled students with score 70% or higher in summative assessment tools. Table 1 contains the CLOs for each considered course. The assessment report for each course contains the following points:

* The CLO attainment results and analysis remarks
* General comments on any problems encountered with the course
* Recommendations
* Implementation of recommendation actions.

**Table 1:** *Course Learning Outcomes for each course*

|  |  |  |
| --- | --- | --- |
| **Courses** | **CLO#** | **CLO statement** |
| GENG215 | 1 | Identify ethical and professional issues pertaining to personal integrity, and professional conduct pertaining to the society and the environment |
| 2 | Recognize an engineering ethical dilemma and apply a systematic process of moral and ethical reasoning to resolve it |
| 3 | Analyse several moral theories and principles (e.g., utilitarianism, duty ethics, virtue ethics, and religious ethics) and apply them to the examination of ethical issues in engineering |
| 4 | Analyse case studies of conflict in Engineering and make choices based on engineering ethics codes and apply one to the resolution of an ethical dilemma |
| 5 | Identify the value of teamwork and multi-discipline work in relation to types and scales of projects through assignments and group projects |
| 6 | Apply the design process using systematic design methods and identify the related professional responsibilities and ethical issues |
| GENG220 | 1 | Explain the basic concepts of macroscopic thermodynamics |
| 2 | Explain the properties of pure substances |
| 3 | Explain the heat transfer and work interaction between a system and its surroundings |
| 4 | Apply the first law of thermodynamics for closed and open systems |
| 5 | Explain and apply the Second law concepts |
| 6 | Analyse thermodynamic processes and cycles within the conceptual frameworks of the First and Second laws |
| 7 | Use the Engineering Equation Solver (EES) learning tool to solve thermodynamics problems |
| GENG315 | 1 | Explain the principles of engineering economy and the engineering economic analysis procedure |
| 2 | Describe some of the basic cost terminology and concepts used in engineering practice |
| 3 | Explain the concept of price demand relationship |
| 4 | Describe the different techniques used for cost estimation |
| 5 | Explain the concept of the time value of money |
| 6 | Evaluate a single project and select among alternative project options |
| 7 | Explain the concepts of entrepreneurship and discuss different elements of a business plan |

**3. Data Collection and Analysis**

Table 2 summarizes the learning outcomes for each ERU course taken by AE students which have been analyzed in term of level of achievement and compared with the overall achievements at the college levels including all programs. Indeed, some of the CLOs for the GENG 215 and GENG 220 are below the attainment level (70%) for the students enrolled in AE program. Although 69% attainment is registered in CLO2 by AE students in fall 2019, the rest of the CLOs attainments are higher than the threshold and are comparable to the overall achievements at the college levels. The AE students’ performance are below 70% for CLOs 3 and 5 in GENG 220 which are related to the knowledge of heat transfer and the second law concept, respectively. On the other hand the overall students at the CE registered low attainments for the both same CLOs which could have explained either by the complexity of the assessments tools related to the CLOs or by the non-adequacy of the tools used to assess these CLOs. In the same course low attainments are registered in three CLOs by the AE students in fall 2020. The attainment levels are 62, 62 and 65 for CLO1, CLO3, and CLO4, respectively. One of the main reason of such drawback in the attainment levels of the three CLOs is due to the online classes offered in the fall 2020 which represent a challenge for both instructors and students. Indeed, the students and instructors were not that prepared to tackle different situations, opportunities, and problems associated with the online scenario.

**Table 2:** *Level of achievement of CLOs for each ERU course*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Major** | **Number of students** | **CLO# [%]** | | | | | | | **semester** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| GENG215 | BS in AE | 13 | 72 | 69 | 79 | 82 | 98 | 87 |  | Fall 2019 |
| Overall | 230 | 75.2 | 74 | 80.2 | 82.4 | 93.5 | 83 |  |
| BS in AE | 17 | 86 | 84 | 89 | 80 | 85 | 90 |  | Fall 2020 |
| Overall | 256 | 81.7 | 84 | 82.8 | 82.5 | 87.8 | 86.3 |  |
| BS in AE | 12 | 80 | 80 | 85 | 78 | 95 | 70 |  | Spring 2020 |
| Overall | 211 | 78 | 79 | 83 | 79 | 92 | 79 |  |
| GENG220 | BS in AE | 28 | 85 | 82 | 69 | 77 | 58 | 79 | 93 | Fall 2019 |
| Overall | 296 | 80 | 81.4 | 62.8 | 73.8 | 67.3 | 72.8 | 89.3 |
| BS in AE | 28 | 79 | 80 | 79 | 70 | 87 | 80 | 90 | Fall 2020 |
| Overall | 218 | 79.1 | 80.5 | 73.2 | 75.2 | 90.8 | 85.1 | 89.2 |
| BS in AE | 13 | 62 | 74 | 62 | 65 | 85 | 75 | 92 | Spring 2020 |
| Overall | 182 | 74 | 82 | 73 | 79 | 82 | 78 | 91 |
| GENG315 | BS in AE | 19 | 87 | 80 | 72 | 76 | 89 | 78 | 82 | Fall 2019 |
| Overall | 229 | 85.5 | 76 | 79.6 | 75.9 | 87.9 | 79.1 | 78.2 |
| BS in AE | 24 | 86 | 91 | 85 | 80 | 92 | 76 | 96 | Fall 2020 |
| Overall | 237 | 85.4 | 87.4 | 86.3 | 79.4 | 88.6 | 78.1 | 90.3 |
| BS in AE | 10 | 85 | 74 | 73 | 81 | 84 | 73 | 78 | Spring 2020 |
| Overall | 161 | 76 | 76 | 88 | 78 | 83 | 80 | 78 |

The second part of this analysis is related to the comparison of CLOs attainments of one sample course for two consecutive semesters in fall 2019 and spring 2020 for all students in CE as shown in Table 3. The course sample considered for this analysis is GENG 215 and the number of sections with achievements lower than 70% for each CLO are reported for each considered semesters and a list of recommendations has been set for remedial actions. We should mention her that in fall 2019 seven sections have been assessed and in spring 2020 five sections have been assessed as shown in Tables 4 and 5.

**Table 3:** *CLOs attainment of CE students in the three courses*

|  |  |  |
| --- | --- | --- |
| **CLOs** | **Number of section with attainment < 70%** | |
| **Fall 2019** | **Spring 2020** |
| 1 | 2 | 1 |
| 2 | 1 | 0 |
| 3 | 0 | 0 |
| 4 | 1 | 2 |
| 5 | 0 | 0 |
| 6 | 0 | 2 |

As a first observation on the results in Table 3, one can say that although the number of sections in spring was 5 but five sections registered an attainment lower than 70% during the online teaching. The most affected course learning outcome is the CLO#6 which deals mainly with the application of the design process using systematic design methods and identifying the related professional responsibilities and ethical issues. Due to the sudden decision taken by the UAE University administration to carry on the rest of the spring semester from mid of March to end of May using online teaching, the students and instructors were not that prepared to tackle different situations, opportunities, and problems associated with the online scenario. Higher order thinking skills with more detailed explanation of the design methods and their relation with the professional responsibilities and ethical issues by providing more assignments will be given more attention in the future.

**Table 4:** *Sections with number of enrolled students in fall 2019*

|  |  |  |
| --- | --- | --- |
| **SEC#** | **Gender** | **Enrolment** |
| 01 | Male | 41 |
| 02 | Male | 39 |
| 51 | Female | 40 |
| 52 | Female | 34 |
| 53 | Female | 26 |
| 54 | Female | 22 |
| 55 | Female | 29 |

**Table 5:** *Sections with number of enrolled students in spring 2020*

|  |  |  |
| --- | --- | --- |
| **SEC#** | **Gender** | **Enrolment** |
| 1 | Male | 58 |
| 2 | Male | 57 |
| 3 | Male | 52 |
| 51 | Male | 31 |
| 52 | Female | 58 |

The attainment levels of the six CLOs for GENG 215 for the two successive considered semesters is shown in Fig.1. Indeed, one can see as an average there is no significant discrepancies between the direct and indirect attainments for both semesters. However, the indirect attainment levels of CLO5 and CLO6 are not in line with the direct one for the spring 2021 semester. This could be attributed to the mixture of face to face and online teaching methods during the semester.

**Figure 1:** The GENG215 CLOs attainment levels for two successive semesters

**4. Conclusion**

The common engineering courses taught in college of engineering at UAEU which includes GENG215 (Ethics), GENG220 (Thermodynamics), and GENG315 (Economics) have been assessed in term of level of attainment for each course CLOs for Architectural Engineering students and compared with all the students enrolled in college of engineering. This study is summarized as follow:

* The CLOs of GENG 220 course are the most “negatively” impacted compared to GENG 215 and GENG 315. Indeed, the attainment of CLO3 and CLO5 are below 70% in fall 2019 and CLO1, CLO3, and CLO5 are lower than the threshold in spring 2020. This could be explained by the nature of this course which deals mainly with physical phenomenon and theory of thermodynamics which require more interaction between student and instructor compared with the two other courses. This is not only applied to AE students but the same tendency is observed for all the students enrolled in college of engineering particularly in fall 2019.
* Another reason of such drawback in the attainment levels of the three CLOs is due to the online classes offered in the fall 2020 which represent a challenge for both instructors and students.
* The comparison of CLOs attainment for two consecutive semesters in fall 2019 and spring 2020 for all students enrolled in college of engineering in GENG 215 course indicates that the most affected course learning outcome is the CLO#6 which deals mainly with the application of the design process using systematic design methods and identifying the related professional responsibilities and ethical issues. This drawback is mainly due to the sudden decision taken by the UAE University administration to carry on the rest of the spring semester from mid of March to end of May using online teaching. The students and instructors were not that prepared to tackle different situations, opportunities, and problems associated with the online scenario.

This initial study should be extended to other courses taught in College of Engineering at UAEU with more focus on the new tools that should be implemented in online teaching and assessment methods for each course and more attention should be given to courses with design component.

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