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Correlation of Student Attainment for Civil Engineering Design Project and Structural Concrete and Steel Design for Undergraduate Students in Concurrent Semester

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Abstract

Structural Concrete and Steel Design(ECSXXX) and Civil Engineering Design Project(ECSYYY) are two (2) compulsory subjects in most studies of Diploma of Civil Engineering in Malaysia. These subjects have been associated with each other as the structural concrete and steel design has carried the theory and fundamentals to the design project subject. ECSXXX which indicates the study on the reinforced concrete of beam, slabs, column, and foundation. Complementary to these, the design of steel beam, column and connections are also included in the syllabus. All the topics will imply in the subject of ECSYYY, whereby students are required to design manually and software for a two-story house. The previous study plan for Diploma Civil Engineering in UiTM Johor was designed that the subject of ECSXXX was under semester 5 and the subject ECSYYY was at semester 6. However, to fulfill the requirement of the Engineering Technology Accreditation Council (ETAC), current study plan was established which combined the two subjects in semester 5. As a result, a single semester 6 will be allocated for the Industrial Training. Due to this system, student attainment based on grade and PO should be analysed. Data recorded all students pass the minimum indicator for PO2,P03,PO4,PO5,PO8 and PO10 using i-Ras. Hence, correlation of overlapping PO such as PO3 and PO4 were analysed for betterment of continual quality improvement can be done in future. Students scored better grades for ECSYYY compared to ECSXXX.

Keywords: Structural Concrete and Steel Design, Civil Engineering Design Project, Engineering Education

Introduction

Diploma in Civil Engineering (EC110) has been offered by Universiti Teknologi MARA (UiTM) Pasir Gudang since 2014, where the campus has just launched. The diploma has graduated thousands of students with accreditation by the Malaysia Qualifications Agency (MQA) and

recently by the Engineering Technology Accreditation Council (ETAC). ETAC has the aim to ensure that graduates of the accredited engineering technician education programmes satisfy the minimum academic and practical requirements for the registration as engineering technician or inspector of work with the Board of Engineers Malaysia (BEM).

One of the requirements from ETAC is to have Industrial Training for 16 weeks to one year duration. This is equivalent to a minimum of one semester. Due to this requirement, the new study plan for Diploma in Civil Engineering (EC110) has been established. Besides 35 subjects under this study plan, two subjects are significantly discussed in this paper. Structural Concrete and Steel Design (ECSXXX) and Civil Engineering Design Project (ECSYYY) are two core subjects that must be taken by the final year students.

Previously, the study plan was arranged as the subject ECSXXX was in semester 5 and the subject ECSYYY was in semester 6. To be specific, the ECSXXX was the pre-requisite subject to the ECSYYY. This requires the students to pass the ECSXXX at first before they can register the subject ECSYYY.

Civil Engineering Design Project consists of manual and software design based on Eurocode 2 (EC2) for a two story house. The project outputs will vastly depend on the study on subject ECSXXX. Generally, the lesson weekly plan for the two subjects will be well prepared by the lecturers. So, the students will learn concurrently for each topic. At the end of the semester, the lecturers conducted the analysis of all the attainments on the Course Outcomes (CO) and Programme Outcome (PO).

The Programme Outcomes (POs) that has mapping to the subject ECSXXX are PO2; Identify and analysed well-defined engineering problems reaching substantiated conclusions using codified method of analysis specific to their field of activity, PO3; Design solutions for well-defined technical problems and assist with the design of systems, components or processes to meet specified need with appropriate consideration for public health and safety, cultural, societal and environmental considerations, PO4; Conduct investigations of well-defined problems, locate and search relevant codes and catalogues, conduct standard tests and measurements.

The Programme Outcomes (POs) that has mapping to the subject ECSYYY are PO3; Design solutions for well-defined technical problems and assist with the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. PO4; Conduct investigations of well-defined problems; locate and search relevant codes and catalogues, conduct standard tests and measurements. PO5; Apply appropriate techniques, resources, and modern engineering and IT tools to well-defined engineering problems, with an awareness of the limitations. PO8; Understand and commit to professional ethics and responsibilities and norms of technician practice. PO10; Communicate effectively on well-defined engineering activities with the engineering community and with society at large, by being able to comprehend the work of others, document their own work, and give and receive clear instructions.

Since, there is no discussion on the impact of having theoretical courses and practical courses being offered in the same semester for the same student. Therefore, there is a need of monitoring the student understanding on three learning domains based on cognitive, affective, and psychomotor domain for final year students if the theory subject and practical subject is being taught in concurrent semester based on grade and POs attainment for both courses using different tools of assessment. Hence, to observe the correlation of POs

achievement (PO3 and PO4 due to being identical of both POs) of the same sample of students in ECSXXX and ECSYYY by considering different tools of assessment.

Literature Review

Outcome Based Education (OBE) is student-oriented, deemed as one of the great education systems that can demonstrate students' learning outcomes (LO), course outcomes (CO) and programme outcomes (PO) upon the completion of any course or any programme. In other words, OBE is a method of approach in designing a comprehensive education system starting from planning, delivery, and assessment that involves all stakeholders such as top management, administrators, educators, and students in making efforts to achieve targeted learning outcomes (Damit et al., 2021). In the engineering field, ability to demonstrate good knowledge, skills and attitudes define the success of an engineering graduate (Jadhav et al.,2022), and the quality standard relies on the programme outcomes, assessment, measurements and comparison to meet goal values (Abdeljaber & Ahmad, 2017). In Malaysia, Engineering Technology Accreditation Council (ETAC) works in line with the Board of Engineers, Malaysia (BEM) in charge of accreditation of engineering technology degrees and engineering technician qualifications. According the manual of ETAC (Standard, 2020), students of an engineering technician diploma programme are expected to attain the twelve graduate attributes (or so called programme outcomes) (1) knowledge, (2) problem analysis, (3) design of solutions, (4) investigation, (5) modern tool usage, (6) the engineer and society, (7) environment and sustainability, (8) ethics, (9) individual and teamwork, (10) communications, (11) project management and finance and (12) life-long learning. Any certified engineering programme would certainly be able to prove its quality through the success of OBE implementation, by means of PO achievement as well as curriculum, teaching-learning, assessment and accreditation (Bhuyan, 2021).

Once the CO and PO of a course have been mapped, learning activities as well as the parallel assessment tools need to be designed to ensure the objective of OBE is achieved. Parallel assessments not only provide evidence on a student's achievement but also stimulate the students' willingness to carry out any learning activities (Ragmat, 2011). Hasan et al., (2021) pointed out the importance of a lecturer's awareness and full understanding of the programme outcomes and the assessment tools for a course, hence cultivating a more effective teaching and learning environment. Assessments of PO for a certain course are commonly carried out in either formative approaches (e.g. assignment, report, project, quiz and presentation) or summative approaches (e.g. final exam, test), or combination of the two approaches. The three domains namely cognitive, psychomotor and affective in engineering attributes affect the choice of method in measuring PO of a student. Most importantly, the measurements need to be clear and specific (Mohammad et al., 2012) in ensuring the quality of engineering graduates. On the other hand, attainment of PO can be calculated by direct and indirect tools in which the direct tools refer to class tests, assignments, tutorials, projects and placements while indirect tools include exit survey, alumni survey, employer survey and curriculum feedback (Rajak et al., 2019). Despite the assessment tools being crucial in the OBE process, a study by Jadhav (2020) indicated that 55% of the sample respondents (educators) were not well-versed about all assessment tools in fulfilling the criteria of LO, CO and PO. Therefore, this study focuses on the attainment of PO and the assessment tools.

In the field of civil engineering, the major difference between structural design course and design project course is the composition of cognitive domain embedded in the POs. In this study, Structural Concrete and Steel Design (ECSXXX) consists 90% of cognitive domain

while Civil Engineering Design Project (ECSYYY) covers only 20% of cognitive domain. Assessment for cognitive domain stated in PO2 (problem analysis) and PO3 (design of solutions) for ECSXXX was carried out by both assignment and final exam. The measurement of the cognitive domain, PO3 in ECSYYY was conducted through a common test. The psychomotor domain stated in PO4 (investigation) is evaluated through mini project and project report in ECSXXX and ECSYYY, respectively. Another highlight in the design project course is the attribute of modern tool usage (PO5) which can demonstrate students' ability in applying appropriate techniques, resources, and modern engineering and IT tools to well-defined engineering problems, with an awareness of the limitations. A direct tool (practical test) was employed in the assessment of this PO. Compared to structural design courses, affective domains in PO8 (ethics) and PO10 (communications) are crucial to be measured by means of the individual project, report and presentation in ECSYYY. Studies on the attainment of PO of a certain course in engineering programme (Isa, 2019; Osman, 2011; Rajaee, 2013; Wee at al., 2021) are greatly available in literature, but very little investigate the relationship between the same PO in two different relevant courses. Hence, this study aims to find out the correlations of POs achievement (PO3 and PO4 due to being identical of both POs) of the same sample of students in ECSXXX and ECSYYY by considering different tools of assessment.

Methodology

This study was conducted to all 143 students who have registered for the course ECSYYY and ECSXXX for session October 2021 -Mac 2022 in the same semester. The aim of this study is to monitor the student understanding on three learning domains based on cognitive, affective, and psychomotor domain for final year students if the theory subject and practical subject is being taught in concurrent semester and to observe the correlation of POs achievement (PO3 and PO4 due to being identical of both POs) of the same sample of students in ECSXXX and ECSYYY by considering different tools of assessment. ECSXXX is identified to be lecture based class for the theory part. ECSYYY is designed to be practical based on prior knowledge from ECSXXX. The assessment for both courses is mapped as Table 1(a) and Table 1(b). There are four (4) main components of assessment for ECSYYY are written test, Practical test, Technical Report, and oral presentation which include cognitive (C), affective (A) and psychomotor (P) domain as stated in Table 1 (b). Meanwhile ECSXXX only assesses on cognitive and psychomotor domain via mini project, assignment, and final exam as stated in Table 1 (a).

ECSXXX is only measured on 3 main POs which are PO2, PO3 and PO4. Since, ECSYYY is captured to be capstone courses for Diploma in Civil Engineering, therefore measurement of PO is more comprehensive compared to ECSXXX. POs involved PO3, PO4, PO5, PO8 and PO10 as stated in Table 1(b). This raw data from UiTM e-Result exam system (e-Res) being analyzed using Revolution on Assessment for Student Monitoring System (i-Ras). This system is developed by a group of lecturers from School of Civil Engineering, UiTM Penang in simplifying calculation of programme outcomes and course outcomes at course level. i-Ras being innovative using simple macro excel works as an offline platform in ensuring the confidentiality of the students' result. Lecturers are required to fill in the important information such as lecturer name, course name, assessment distribution percentage at the front page of i-Ras as in Figure 1. Next, the student's name and student should be copied from the student information management system (SIMS) at the second page of the template. Raw data from student attainment for designated PO and CO from e-Res can be paste to i-Ras.

Once raw data is filled in, i-Ras will automatically calculate the final PO and CO for each student and give the overall attainment for the CO and PO at course level. This kind of output is important in preparing accreditation evidence documents to ETAC in reporting student performance using CO and PO, instead of PLO as in e-Res. This is the reason the lecturer needs to analyse the data using i-Ras. Student attainment in Table 1 (a) and Table 1 (b) being normalize to 100% for better comparison in next section.

Table 1(a)
Assessment for Structural Concrete and Steel Design (ECSXX)

Assessment Tool	**Taxanomy**	**Program outcome**	**Total Percentage**	**Duration**
Final Exam	C	PO2 & PO3	60 %	3 hours
Assignment	C	PO2 & PO3	30 %	1 week
Mini Project	P	PO4	10 %	1 month

Table 1 (b)
Assessment for Civil Engineering Design Project (ECSYYY)

Assessment Tool	**Taxanomy**	**Program outcome**	**Total Percentage**	**Duration**
Written test (Common test)	C	PO3	20%	2 hours
Practical Test (Common test)	P	PO5	20%	2 hours
Reinforced concrete project: a. progressive work	A	PO8	20%	14 weeks
b. technical report	A	PO8	10%	14 weeks
Technical report	P	PO4	10%	14 weeks
Project (Oral Presentation)	A	PO10	10%	½ hour
Technical report (Written communication)	A		10%	14 weeks

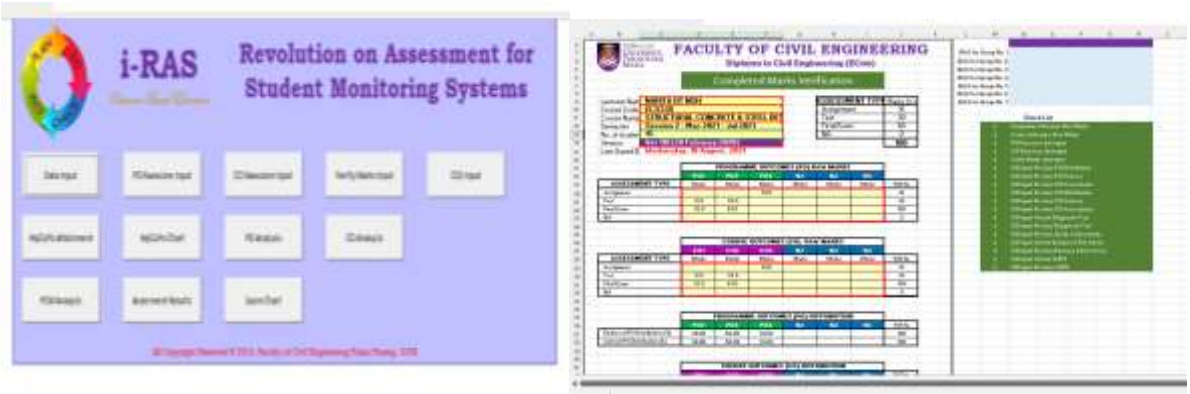

Figure 1: i-Ras template for COPO analysis for EC 110

Student Attainment based on Grades and POs for ECSXXX and ECSYYY

Figure 1 shows student attainment based on overall grade for both courses. Student achievement for ECSYYY is better than ECSXXX. The majority of students ECSYYY scored A-. Meanwhile, for ECSXXX, the majority scored B-. This gap of student performance may be due

to distribution of assessment tools for each course. 60% of assessment weightage for ECSXXX is contributed by the final exam, which requires students to answer the question within 3 hours. Meanwhile, ECSYYY syllabus is designed to be practical oriented, therefore 50% of assessment weightage is progress work within 14 weeks. Based on lesson plan progress work has been subdivided to smaller parts and students are required to submit according to timeline. Hence students have enough time to complete the task and score better compared to ECSXXX.

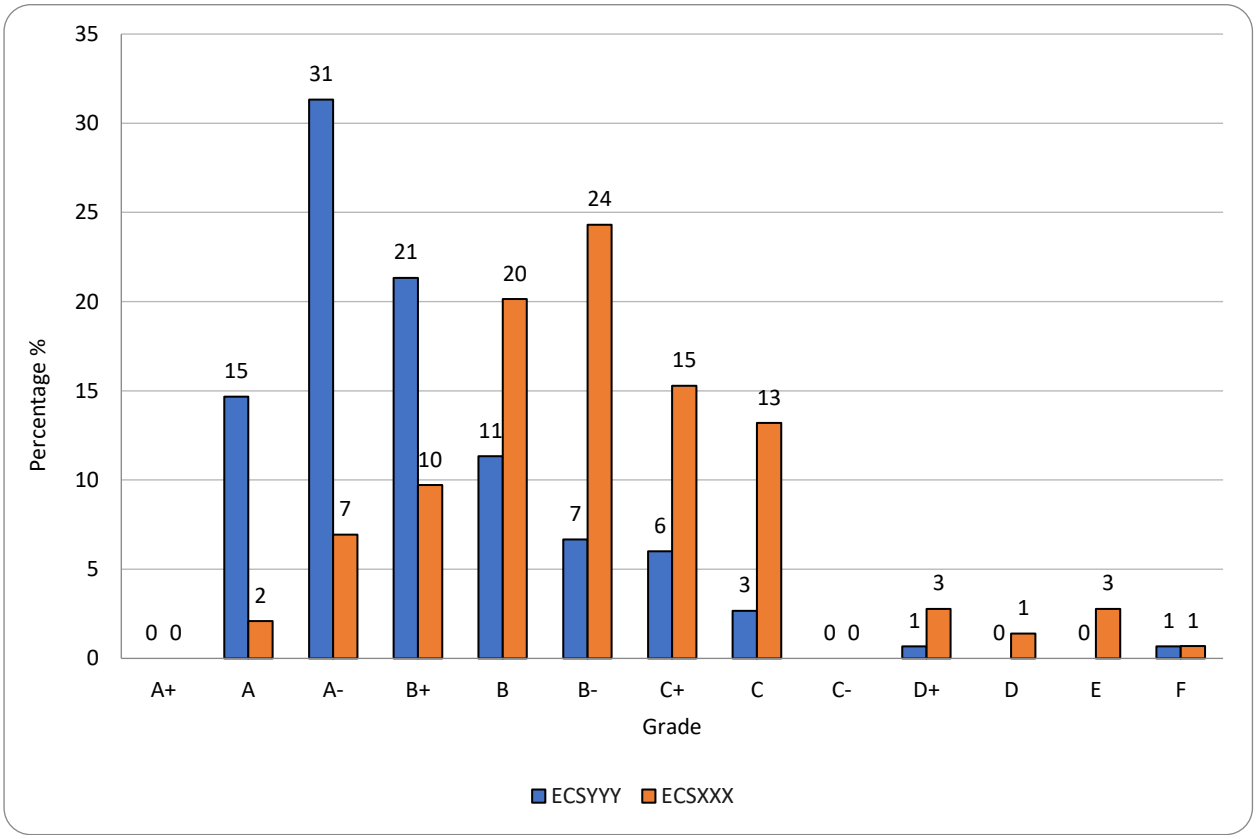

Figure 1: Overall Grade Attainment for ECSXXX and ECSYYY

Meanwhile Figure 2 shows the comparison of POs attainment for ECSXXX and ECSYYY. All students score more than the minimum indicator which is 50% for all POs. Students achieve better in psychomotor domain (PO4) compared to cognitive domain (PO2 & PO3) for ECSXXX. The trend of performance is similar to ECSYYY, where students scored better for effective domain (PO8 & PO10) and psychomotor (PO4 & PO5) compared to cognitive domain (PO3). Students' attainment for PO4 is more than 75% for both courses. This scenario is due to both courses giving sufficient time for students to complete the task. For example, ECSXXX allows students to complete the mini project for 1 week as a group work. Meanwhile ECSYYY allocated PO4 as a technical report which allows students to complete the task within 14 weeks. It shows that students require ample time to understand and solve the task. Meanwhile, ECSXXX recorded 63% of the average score for PO2 (cognitive domain-basic knowledge). However, PO3 (cognitive domain-higher order thinking) recorded slightly lower than PO2 which is 58%. The same student scored lower attainment for PO3 for ECSYYY, which is 53%.

PO5 depicted as 60% as an average score for ECSYYY being assessed for practical tests within 2 hours for each student. Students are required to answer the question using PROCON software to measure psychomotor domain during remote learning. It shows that, student nowadays is 'gadget savvy'. Students achieve better results in communication skill (affective domain) including oral and written communication for PO8 and PO10. Based on Figure 2 students score 82% for PO8 and 79% for PO10. Since ECSYYY is a capstone subject, therefore student is able to apply prior knowledge in communication skills from lower semester but not for cognitive domain (PO3) that is being thought in the same semester.

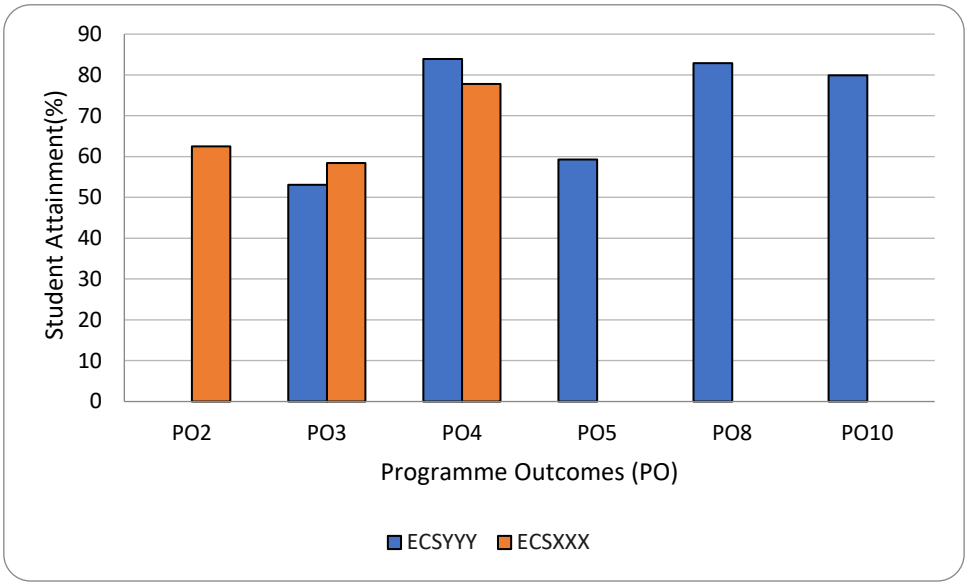

Figure 2: Programme Outcomes attainment for ECSYYY and ECSXXX

Figure 3 shows the correlation of PO3 (cognitive domain) between ECSXXX and ECSYYY for semester October 2021 - Mac 2022. Results show that the correlation between both courses is less significant where the R value is 0.34. It may be due to the cognitive domain for both courses being measured using a common test and final exam. These types of assessment tools seem to be disadvantages for students to score better results. Students only given a specific duration of time to complete a full set of questions cover all chapters that are taught within 14 weeks. ECSYYY only allows for 2 hours common test and ECSXXX allows final exam for 3 hours. It shows that students require longer time to complete the lengthy solution of the design question. Furthermore, students sometimes need more time to digest the knowledge from theory courses (ECSXXX) before practicing for practical classes (ECSYYY).In addition students also lack understanding of the concepts and methods to respond to the final exam questions. It is suggested using the old programme structure which allows students taking theory class during lower semester and practicing the knowledge at upper semester. It is hoped to help the student attainment in cognitive domain and achieve better correlation of PO3.

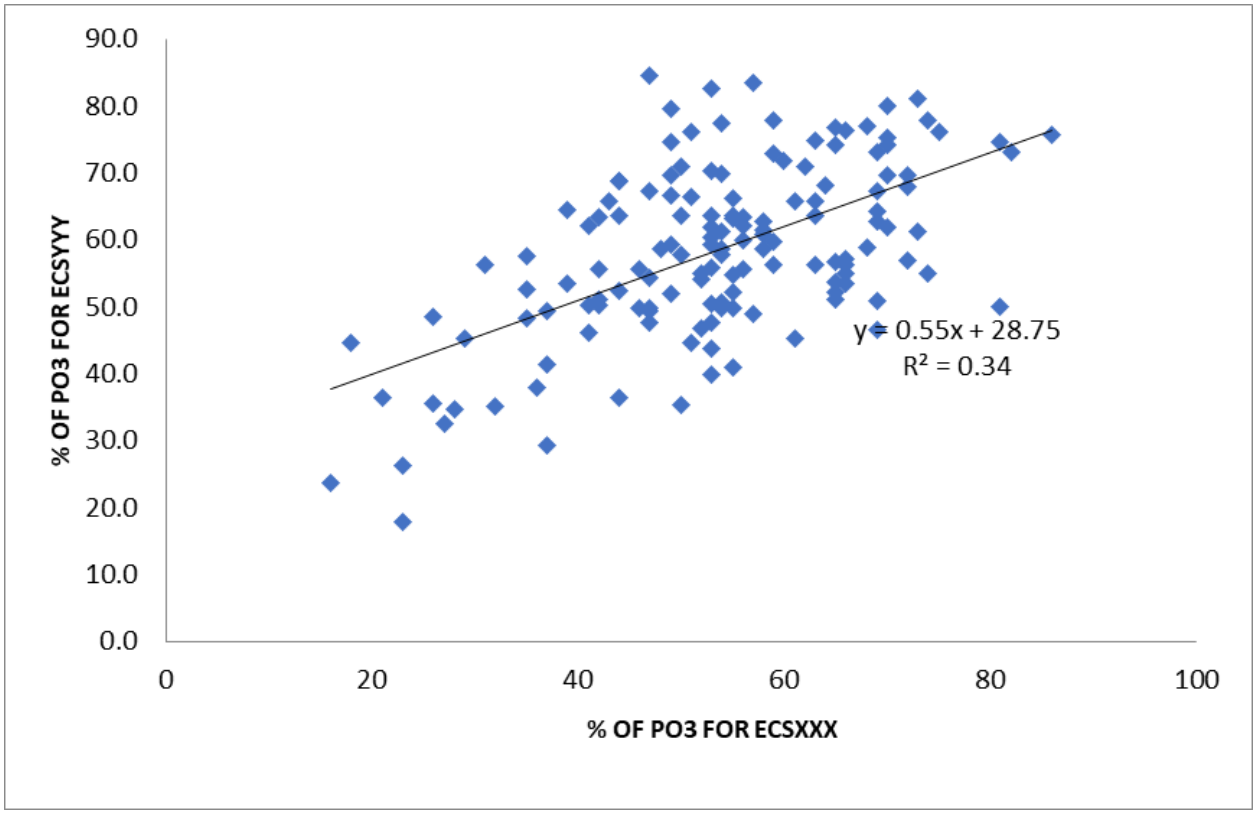

Figure 3: Correlation of PO3 attainment for ECSXXX and ECSYYY

Meanwhile, Figure 4 shows that the correlation between PO4 for both courses is poor. The R value is recorded to be 0.03. Although both courses recorded better results compared to other POs. It might be due to amount of task that being assign to student and individual task or grouping work oriented. ECSXXX only required 1 submission based on simple project dealing with steel design within 1 month duration and students can form small group maximum of 4 students. Steel design is a subtopic in the ECSXXX, therefore student will apply knowledge immediately after lecture hours to solve the task. Total task being assign for ECSXXX is four simple tasks sharing with others team members compared to ECSYYY required student to prepared 8 task as individual work within 14 weeks. Which required student to practice knowledge from lower courses and ECSXXX. Therefore, student required more hard work and effort to complete the task for ESCYYY.

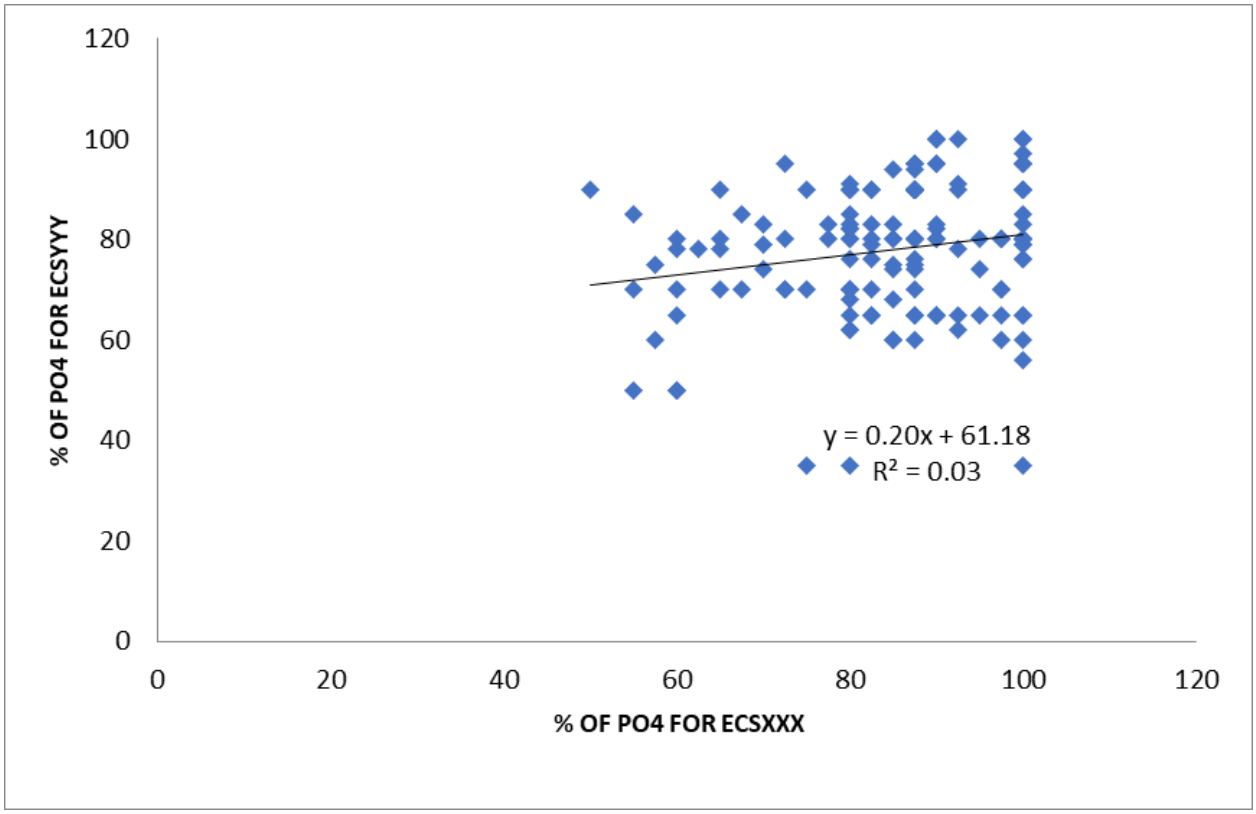

Figure 4: Correlation of PO4 attainment for ECSXXX and ECSYYY

Conclusion

The study revealed that students attain better grades for ECSYYY compared to ECSXXX. However, students score more than the minimum indicator for PO2, PO3, PO4, PO5, PO8 and PO10. In addition, there is a less significant correlation between student attainment (PO3) for both courses if the theory subject and practical subject are being taught in a concurrent semester. But poor for PO4 due task breakdown and individual or grouping work oriented. Students score lower attainment for cognitive domains compared to other domains for both courses.

The comprehensive assessment in the courses is prominent in providing graduates who can apply the theoretical and practical skills in the academic courses. Therefore, it is good if both subjects are being taught in different semester as being discussed by head of department (HOD) for new plan study plan. The student's performance in the cognitive, affective, and psychomotor domains should also be balanced to meet the standards of the field in which students will work. Monitoring using continual quality improvement should be carried out in ensuring the student performance meets the minimum standards as stipulated by college. Hence, it is hoped to improve the teaching, learning and assessment aspect in future.

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