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The Evaluation of Ignation Pedadogical Paradigm Framework to Engineering Ethics Education

(Penilaian Kerangkaan Pedadogy Ignation Paradigm untuk Pendidikan Kejuruteraan Etika)

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ABSTRACT

Teaching and learning in higher education has gone through a series of transformation in recent decades. Engineering education is one area that would be crucial to undergo such transformation due to the complex nature of engineering application in industries today. The problem facing engineering graduates is the ability to competently solve real world problems using the knowledge learnt during their tertiary education. The learning approach towards problem solving and critical thinking weren't sufficiently developed throughout the curriculum. One of the theories of learning that was considered was coined by Piaget, cognitive constructivism theory which uses cognitive tools and in collaboration with the environment learners are exposed to. By incorporating such student-centered learning with group learning would improve the students' achievement in the learning outcome and increase the learning efficacy. This paper describes the application of Ignation Pedagogical Paradigm (IPP) being applied as a model framework in the teaching of one of the courses offered in Bachelor of Mechanical Engineering, i.e. Professional Practice towards strengthening their competencies. By applying a structured formative assessment centered learning environment, the instructor would be able to provide a more holistic learning experience to the students using the cognitive constructivism theory of learning. The results show that the proposed IPP framework is able to complement affectively with the learning theories for engineering education achieving the course outcomes and students would be able to improve their competency in solving complex problem.

Keywords: Engineering education; cognitive constructivism; Ignation Pedagogical Paradigm; formative assessment

INTRODUCTION

UNESCO with its education arm addressed in (Unesco 2018) Education for Sustainable Development (ESD) the importance of creating sustainable citizens in order to contribute to societal transformation towards sustainability. There are eight (8) core competencies highlighted which includes critical thinking competency and integrated problem-solving competency. (Yasin et al. 2011) stressed the importance of a proper framework in realizing the elements of ESD. The key pedagogical approaches that are recommended to form these competencies include learner-centred approach, action-oriented approach and transformative learning.

In 2020, the world Economic Forum highlighted the top 5 skills needed by industries, which also includes complex problem solving and critical thinking. In order to ensure that engineering graduates are able to adapt to this change in environment and the needs of the industries, the curriculum would need to build a life-long skill that enable the learner to learn and re-learn in a rapid environment change.

Engineers solve problems differently in comparison with other professional occupation. (Jonassen 2010) stressed that design problems are suitable for engineers who require to make judgments about a problem and to defend the decision through analysis of constraints, constructing models and optimizing solutions

The engineering learned societies are beginning to stress on the need to build engineers equipped with certain competencies such as the Institution of Engineers Malaysia (IEM) and the Institution of Mechanical Engineers, UK (IMechE). These competencies are needed to fulfil and demonstrate the engineers' capabilities to solve real world problems. If the applications of these competencies are able to be demonstrated throughout the curriculum, then the pedagogy would be crafted in order that the students are able to demonstrate these competencies.

Malaysia is a part of an international alliance agreement that consists of bodies around the world responsible for accrediting engineering programmes, which is called the Washington Accord. The Outcome Based Education is an educational system adopted to provide a systematic

educational framework with the expectation to ensure engineering students are able to achieve the expected outcomes meeting the needs of the industries. (Liew et al. 2021) stressed the requirements by Engineering Accreditation Council (EAC) under the Board of Engineers (BEM) would require all institutions that offer engineering programmes to meet this requirement.

This research paper aim to investigate the capability of applying a specific framework, called the Ignation Pedagogical Paradigm (IPP) towards its ability to provide students the necessary learning experience to apply their critical thinking skills to solve complex problems. Complex problem solving using IPP would be demonstrated by the students in a specific course offered to the 4th year B. Eng in Mechanical Engineering, Professional Practice. This course was selected as a suitable course, as the instructor would be able to measure and evaluate the capability of students in applying the needed competencies in their engineering practice.

LEARNING THEORIES

According to (Van Grunsven et al. 2021) much of engineering decisions comes with high burden of moral responsibilities that requires explicit ethical reflections. There are more significant number of engineering problems that began to embrace engineering ethics in their curriculum. (Børsen et al. 2021) also reported that universities should not only teach micro ethics to engineering students, but also introduce a critical macro level ethics. The curriculum should be designed to provide real life experience and to provide the necessary competencies to manage the ethical dilemmas faced by engineers. Therefore, ethics education is a crucial course in ensuring students are competent enough to solve engineering related problems.

Some research studies such as by (Kowalski et al. 2014) highlighted the importance of formative assessment in order to reach the full potential of student-centred learning. With formative assessment comes the requirements of the assessment process. (Rust et al. 2005) highlighted the importance of the right feedback mechanism, as without it, the assessment process would be deficient.

According to (Zuljan et al. 2021) it was highlighted that in order to create an efficient learning environment, it would require student centred learning with a combination of team cooperative learning as it would improve students learning outcome and would be effective for students learning in science related subjects. Furthermore, (Swan et al. 2009) stressed in the research that as the learner interacts with the physical social and mental world, the learner would make sense from their experiences by building from the internal knowledge gained earlier. Therefore, learning is tied to experience, which relates to the constructivist theory of learning. (Yampinij et al. 2012) also emphasized that students needed to encounter real world problems in order to construct new knowledge. Furthermore, (Peters 2015) stressed that through his research work, in practice, undergraduate students find it difficult to link their prior knowledge to solve complex real world problems in engineering education. This is the cause of why problems from the industries are not solved effectively.

Problem solving skills in the context of OBE is an important competency for engineers to solve real world issues, thus the term complex problem solving is an important learning term used in engineering education (Jonassen 2011). This complex problem-solving term relates closely to solving ill-structured problems as there are no one fixed all solution in the engineering field. Engineering education therefore would require structured assessments through proper construction of rubrics for students' effective learning (Ahern et al. 2019). According to (Liew et al. 2020), formative assessment plays a key role in not only strengthening the complex problem-solving skills, but also the life-long learning skills needed to overcome a vast range of industrial problems that needed engineered solutions.

Two learning theories that relate to the active learning of students are the cognitivist and constructivist theory of learning, as it strengthens the learners' ability to solve complex problems through student centered learning (Mattar 2018). The cognitivist theory relates to the reflective element used in the IPP framework in order to grasp the significance of the problem towards the subject matter. The constructivist theory relates to the action that was decided upon and the process to evaluate the decisions made in solving a specific complex problem. These theories will be used as the theoretical framework in the formative assessment approach of this research study. Formative assessment plays a key role in students learning as it provides relevant feedback to correct students' misunderstandings and misconceptions and frame their problem-solving skills to improve their learning (Kowalski et al. 2014).

The Ignatian Pedagogical Paradigm framework has the required components built in to support such formative assessments described, and has the centuries of the necessary historical foundation in ethical studies. With its feedback component within its framework and its ability to relate to real world problems, the IPP would be suitable in applying the cognitivist constructivist theory of learning.

IGNATIAN PEDAGOGICAL PARADIGM (IPP)

The Ignation Pedagogical Paradigm (IPP) is a 450-year-old approach to education based on St. Ignatius of Loyola that takes a holistic view of the world and applies 5 elements of learning; context, experience, reflection, action and evaluation. According to (Vincent 2017), this IPP framework was created and used in the Jesuit education since 1599, and has been used as a formation of the human person through academic as well as complex values of life (Massey 2008). It seeks to transform how youth looks at themselves and others at the global community and will be able to result in the radical transformation in the way they live in the world

seeking greater good to enhance the quality of peoples' lives (Mauri et al. 2015)

According to (Mcavoy 2013), the application of IPP in the College of Professional Studies facilitates the acquisition of higher order thinking skills and provides the best practices in the field of cognitive learning. The official document Ignatian Pedagogy – A Practical Approach by (Vincent 2017) clearly describes the application of the IPP framework and describes how the transformation of the learners' thought process through the constant interplay of experience, reflection and action. The limited research of IPP has not been established and proven in the context of engineering education, therefore this research intends to evaluate its significance through engineering ethics education.

Starting with context, the teacher becomes aware and conversant of the life experience of the learner. The teacher learns about the students' point of view and thinking and the experiences that they have gone through that shaped their thinking and behaviour. This phase would be important to understand and shape the learning methods to deliver the materials appropriately. The knowledge of context would be able to create a more conducive student centred learning, rather than just a knowledge transfer process only. It allows the teacher to engage the students through the right delivery methods in order that the students would be able to relate the prior knowledge learnt to their lives affectively.

The second phase, experience relates the students cognitive understanding of the matter towards the affective nature of the students (engages the head to the heart). This phase would involve the learner to go beyond rote knowledge towards more complex learning skills. This stage provides active learning where the learner would think about what they are doing. It would require learner to move outside of their comfort zone that would challenge their belief structures towards uncertainties through cases and situations.

The third phase is reflection, where the IPP stands out from many other traditional learning frameworks as this is where the teacher acts as a facilitator in guiding the learner to reflect on their experiences. The transformation of students learning begins through the learners' reconsideration of the subject matter and grasping the significance of the experience.

The fourth phase is action, where through the learners' reflection, the manifestation of their choices would take place. Through the learners' reflection, the action is the manifestation from either interior or exterior, and it would move the learner to act upon it. Especially for a professional occupation such as engineering, the goal of the learning process is for the learner to act upon their experience serving the public interest woven into their course to serve the public interest, or be the "public watchdog" through their action needed to be taken.

The final phase is evaluation, is where the assessment of the learning outcomes is measured. This could involve the evaluation of proficiency of the subject matter, or through the students' growth in maturation. In cognitive perspective, students increased intention to solve certain issues addressed could be observed. The formative assessment would provide the holistic perspective to guide the student towards learning more effectively.

METHODOLOGY

A case study was conducted using the course, Professional Practice offered to final year undergraduates in mechanical engineering programme. This case study was chosen because it covers the area of engineering ethics. As the final year students have almost completed their academic studies, with their fundamentals and advanced knowledge of engineering theories and skills learnt, students are expected to evaluate their engineering decisions in real life and its impact made to society and the environment. Using the IPP framework, students are required to synthesize their engineering knowledge and evaluate their decisions towards various stakeholders who would be impacted by such decisions. The IPP framework is used by the instructor throughout their formative learning in a specific project, where students' performance will be gauged throughout the project duration of 5 weeks.

The instrument that is used to assess the students' competency is though their recorded virtual presentation work and a rubric is given prior to their project to ensure they are aware on the expected outcomes. Through the 3 stages of presentations and individual question and answer sessions, their ability to relate and evaluate their project work independently against the required competencies for problem solving were measured and evaluated by the instructor. The results of each stage of presentation and question and answer are tabulated and compared in order to assess the effectiveness of the IPP framework.

Samples are taken from 2 groups of cohort data, the first in the August 2021 semester, and the second group is the Jan 2022 semester. These samples are the only group of students enrolled in the Professional Practice course for both the semester. Each group samples and results are independent of each other, with the purpose to validate the results independently to provide a greater significance in the outcomes. Each cohort isn't related in anyway and does not have any relationship that would affect each other's outcome.

The data collected is the students' formative results within the 5 weeks. The results are to be compared between the initial assessment, mid-point assessment and final assessment of formative assessment. A descriptive statistical analysis will be conducted to summarize the characteristics of each data and compare the relationship between one stage of assessment to another. Through the regression analysis, the results would be able to reflect if there's a correlation between the first assessment against the mid and against final formative assessment. The summative assessment results data mean using the IPP framework will further be compared

against the non-IPP conventional approach conducted prior to the project with the similar course outcome in order to evaluate the IPP framework effectiveness.

In terms of statistical analysis, the first analysis involves the use of Pearson Regression to measure if there's any linear association between different stages of formative assessment. Secondly, a correlation coefficient will be done to measure the strength and direction of the linear relationship each of the data set. Thirdly, an analysis of variance will also be done to ensure that the data values of different stages of formative assessment are statistically significant with each other. Finally, the mean percentage of the summative results between the IPP framework and the non IPP conventional framework is also to be measured and compared to gauge if there's any correlation with each other and its impact from the different framework. Each cohort will be evaluated separately in order to see if the results validate each other.

In the case of Professional Practice, one of the course outcomes used was a case study as part of the course assessment, i.e.:

CO1: Upon completion of this course, students will be able to describe the professional conduct of an engineer in the work environment.

In order to plan the use of the IPP framework for this course outcome. A group project was developed which has a weightage of 10% of the total assessment marks for this course. The duration of this project is 5 weeks long, where students are divided in groups of 3-4 students to work together in delivering the project objectives. The August 2022 semester, consist of 31 students in total, 9 groups of students were assigned to the project. The Jan 2022 semester consist of 14 students in total with 4 groups in total. The specific project objective is for students to be able to elaborate the needed competency of any engineer involved in an external industrial project to work towards being qualified in reaching the status of a professional engineer in Malaysia. Students were required to provide a brief presentation of their findings structured using the FIVE (5) elements referring to Figure 1.

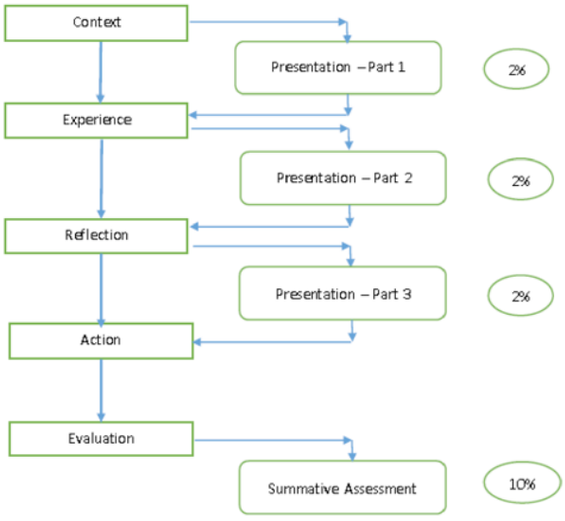

FIGURE 1. Research Framework Flowchart

Context

The pre-requisite for this course is internship and from the students' background, all enrolled students were required to complete their internship experience in order to go through this course. Their internship experiences were shared by everyone on the various industrial exposure they have encountered and the what were their observations of the engineers they encountered. Their previous industrial projects completed such as the Engineering Design Projects were also considered as an experience the students have undergone for at least 2 semesters (28 weeks) prior to this course with sufficient complexity in dealing with the problem with an industry. The five (5) competencies of an engineer were discussed and their observations were taken note of, i.e., were the engineers professional in their conduct dealing with engineering work, problem solving, project management, communication skills and ethical with safety and health issues. The students' observations shown a wide range of positives and negative observations, which were an important part of their learning and their thought process of what an engineer needs to do in the "field". This is their foundation of understanding that needs to be built on.

EXPERIENCE

Bridging from their background, students were then briefed on the routes to be a professional engineer upon graduation that are available, the procedures and requirements needed to be applied in order to become a professional engineer. The importance of the required five (5) competencies that are needed by the Board of Engineers (BEM) in order to meet the minimum requirements of a professional engineer were explained and elaborated. The instructor discusses on the challenges and the need to be the "watchdog" to society in order to ensure that the integrity of the work and tasks done are crucial for the safety and health of society.

REFLECTION

Students are then further required to use any of the past Engineering Design Projects (EDP) they were involved in. Students are expected to be critical in their defence and to elaborate if their effort and work put in during their project execution was sufficient in achieving all the necessary FIVE (5) competencies with proper defence in their arguments. Students were required to submit a virtual video presentation of their learning in meeting the competencies through the projects that were done. Their reflections are presented and the instructor provided the necessary questions and feedbacks upon observing their group video presentation. The instructor would be able to gauge the effectiveness of the group members' individual critical thinking in order to assess if the learning outcomes were achieved. A three (3) stages of video presentation were done on a weekly basis in order to provide sufficient feedbacks within the various hierarchy of complexity.

ACTION

Students are then required to fill and submit the necessary forms, reports and documentations to the instructor similarly to the Board of Engineer for engineers in the field in order to apply to become a Professional Engineer. In order to be able to fulfil the requirements for a professional engineer, students were needed to provide sufficient elaboration on their weakness areas that needed to be supplemented with further relevant tasks or project work that being an engineer they needed to perform to fill in the needed gaps of their project work. The use of virtual video presentation was able to be support the students' emphasis through their words and emphasis.

Evaluation

The documents were required to be submitted as if they are applying themselves to be a professional engineer, which will then be evaluated and assessed in order to identify if they have achieved the required learning outcome. The evaluation of each individual student could be evaluated through their scope and strength of presentation and their report submission. Further to that, a summative assessment is conducted on the 6th week in order to evaluate the students' capability to apply their knowledge towards a random industrial case study.

Three formative rubrics (parts 1-3) that were used to evaluate the students group presentation through their weekly progress video recording, which then the instructor provides the feedback on their strengths and weaknesses. The rubric reflects the individual performance of each student based on their critical reflections and defence. Students are made aware on the expected tasks required for each level of complexity and the knowledge profile that the students are expected to apply. With these weekly feedbacks, students were able to gauge their level of performance, strengths and weaknesses in their presentation.

RESULTS AND DISCUSSION

Data from a case study was conducted from two semesters of the same course using the same outcome were compared. The first data group from the August 2021 semester with a cohort of 31 students' performance and the second data group was taken from Jan 2022 semester with a cohort of 14 students. The conventional method performance of standard lecture session was compared against the IPP framework in order to evaluate the effectiveness of the IPP framework versus the lecture session. Although the cohorts were different, but the measured outcome reflected were on the same course outcome for both the cohorts for each consecutive semester in order to maintain a constant variable.

For the conventional lecture session, students were given a lecture class on the topic covered and the outcome was measured through the summative test assessment at the end of the 6th week. No follow up on any formative assessment was conducted for conventional session. In the IPP framework, students were grouped in groups of three to four (3-4) and the instructor provided the required expected outcome of the project within the same time frame of 5 weeks. A follow-up on formative assessments was conducted using the 5 elements of IPP framework throughout this time and the summative assessment was only conducted at the end of the 6th week. The below Figure 2 shows the graphical representation of the students' performance for this outcome comparing both frameworks. The x-axis represents the students in the cohort and the y-axis represents the students marks attained.

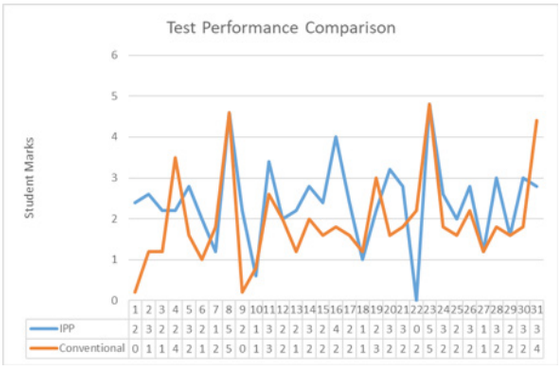

FIGURE 2. Test Assessment Performance of CO1 Aug 2021

From the Figure 2, it is noticed that there is a correlation value of 0.52 which reflects the data between both frameworks are moderately correlated. This reflects that the same students performed in coherent for both the IPP and conventional framework in the summative assessment. No biasness exists between them. A greater observation shows the IPP framework (blue line) achieved an average performance of 10% better compared to the conventional method (red line). The average performance for conventional assessment is 38% (red line) and the average performance for IPP assessment method is 48% (blue line).

Figure 3, displays a similar graph for a smaller cohort and from the graph, the trend reflects quite similar outcomes, as it is observed that there is a correlation value of 0.56 which reflects the data are also moderately correlated. No biasness exists between them. This also reflects that the same students performed in coherent for both the IPP and conventional framework in the summative assessment. The average performance for conventional assessment is 52% (red line) and the average performance for IPP assessment method is 62% (blue line). As a whole, the IPP framework (blue line) also performed 10% better compared to the conventional framework (red line).

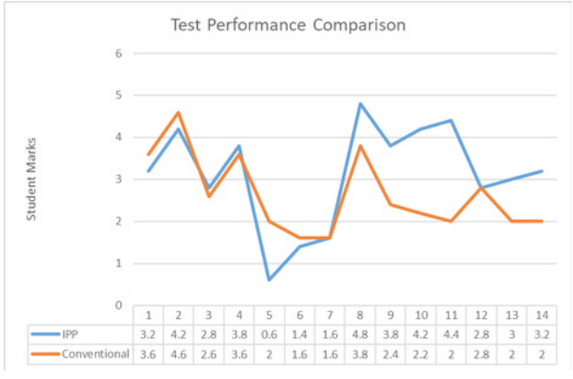

FIGURE 3. Test Assessment Performance of CO1 Jan 2022

In can be concluded that both cohorts support the observation of a similar trend lines and the IPP framework attained an increased performance of 10% in the summative assessment.

The next Figure 4 below shows the graphical representation of the IPP framework for the formative assessment (Part 1-1, 1-2 and 1-3) for the August 2021 cohort. The graph is reflected using the three colours showing their relationship with each other. The initial comparison in the trends shows there is some similarities in the students' performance throughout the 3 formative assessments depicted by the three colours, red, blue and grey. Further detailed comparison shows there is a good correlation between each of these assessments. The correlation factor is between values 0.7 to 0.8. The correlation factor shows that the data have a fairly strong correlation between one another. It can be concluded that each of the three assessment has a similar impact on the students' performance for this course outcome. The IPP assessment impacted each student's performance progressively at every stage of the formative assessment.

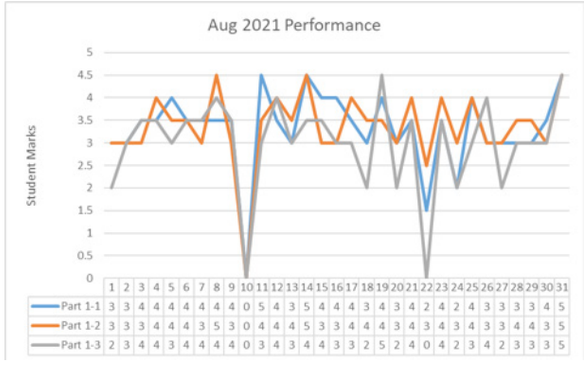

FIGURE 4. IPP Assessment Performance of CO1 August 2021

Figure 5 is also result from the investigation between the three formative assessments of IPP framework, but this time, it is for the January 2022 cohort. The initial comparison in the trends also shows there is strong similarities in the students' performance throughout the 3 formative assessments. Further detailed comparison shows there is also a strong correlation between each of these assessments. The correlation factor is also between values 0.7 to 0.8. The correlation factor shows that the data have a fairly strong correlation between one another. It can be concluded that each of the three assessment has a similar impact on the students' performance for this course outcome. The IPP assessment impacted each student's performance progressively at every stage of the formative assessment.

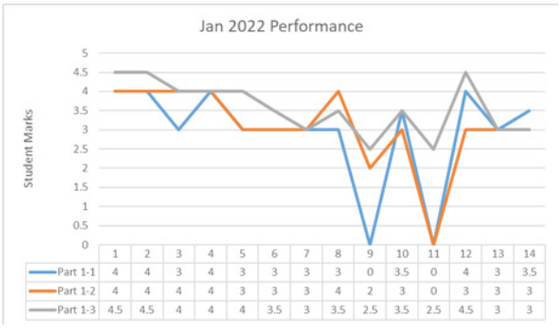

FIGURE 5. IPP Assessment Performance of CO1 Jan 2022

Some of the noticeable comments by the instructor on the differences in observation for both the two cohorts of students are summarized as below:

1. Both cohorts of students, i.e. 31 students in August 2021 and 14 students in January 2022 portrays very similar outcomes in terms of student achievements using the IPP framework and the conventional framework.
2. Students' summative assessment using the IPP framework compared against the conventional framework in August 2021 and January 2022 shows a cohort performance of an average 10% higher on the same expected course outcome. From the assessments results of the conventional framework, students seemed to perform below the expectations of the instructor in achieving the course outcome. This could be because of lesser feedback opportunities has affected lower grasp in students learning on the subject matter.
3. Students' performance using the IPP framework in August 2021 and January 2022 shows a greater grasp of their cognitive and affective domain, noticeably through their elaboration in their reflection on their presentations and reports throughout the continuous monitoring and feedbacks of their work in the 5 weeks' duration. Student were able to apply a higher cognitive reasoning and evaluation of real case problems given. This supports the use of constructivist and cognitive learning theories.
4. From the presentations and summative assessments, the five stages of IPP framework reflects good reinforcements in the capability of students to solve complex problems. This supports the impact of formative assessment provided the necessary environment in learning to achieve the course outcome.
5. Each formative assessment shows a high correlation between each of the three stages of assessments. This reinforces the IPP framework capability which eventually strengthen the students' knowledge and grasps for complex problem solving through its 5 stages.

CORRELATION ANALYSIS

Table 1 shows the statistical results in comparing the summative assessment of students that went through IPP method and its correlation against the conventional method for January 2022 cohort. The result of 0.52 reflects that as a whole, the same students who performed in the IPP assessment performed similarly in the conventional assessment but IPP has an improved average.

TABLE 1. Correlation Between IPP and Conventional Method Jan 2022

	IPP	*Conventional*
IPP	1	
Conventional	0.52	1
	Moderately Correlated	

Table 2 shows the statistical results in comparing the summative assessment of students that went through IPP method against conventional method in the August 2022 cohort. The result of 0.56 also reflects that as a whole, the same students who performed in the IPP assessment performed similarly in the conventional assessment but IPP has an improved average.

TABLE 2. Correlation Between IPP and Conventional Method Aug 2022

	IPP	*Conventional*
IPP	1	
Conventional	0.56	1
	Moderately Correlated	

Both cohort results reflected students who performed well in the IPP method also performed similarly well in the conventional framework, and vice versa. Therefore, there were no indication that students learning was deprived in any way due to any impartiality of either method by the instructor.

Table 3 below shows the correlation between each of the 3 formative assessments in the IPP method for the January 2022 cohort. From the results, the correlation values show a minimum of 0.71 to a maximum of 0.82. This reflects that each assessment is fairly strong in their correlation with each other. Since they are highly correlated it reflects that each part builds on the previous part to provide the learning outcome for the students.

TABLE 3. Correlation Between Part 1 – Part 2 – Part 3 of the IPP Method Jan 2022

	Part 1-1	*Part 1-2*	*Part 1-3*
Part 1-1	1		
Part 1-2	0.82	1	
Part 1-3	0.78	0.71	1
All variables are fairly strong correlated			

Table 4 shows the correlation between each of the 3 formative assessments in the IPP method for the August 2021 cohort. From the results, the correlation values show a minimum of 0.71 to a maximum of 0.80. This reflects that each assessment has a fairly strong correlation with each other. Since they are highly correlated it reflects that each part builds on the previous part to provide the learning outcome for the students.

TABLE 4. Correlation Between Part 1 – Part 2 – Part 3 of the IPP Method for Aug 2021

	Part 1-1	*Part 1-2*	*Part 1-3*
Part 1-1	1		
Part 1-2	0.78	1	
Part 1-3	0.80	0.71	1
All variables are fairly strong correlated			

Both cohort results supported the same outcome and reinforces the stand that formative assessment do impact the students' ability to solve complex problem solving as it gives and reinforces students' prior knowledge to new case and challenge.

REGRESSION ANALYSIS

A further regression analysis was done to find the relationship between formative assessment 1-1 versus 1-2 and formative assessment 1-2 versus 1-3 for Jan 2022 cohort using the IPP framework. The regression model shows that the relationship is linear as observed in Table 5 and 6 below. It could be observed that from the Pearson Regression (Multiple R) value of 0.81 and 0.68 are much above 0.5, and that shows all three formative assessments have a positive relationship with each other. Furthermore, the R Square value shows that 66% of the variation and 47% of the variation lies around the mean. This supports the correlation and it reflects that there is a strong relationship between each formative assessment.

TABLE 5. Regression Analysis for Part 1-1 against Part 1-2 for Jan 2022

Regression Statistics	
Multiple R	0.812783526
R Square	0.66061706
Adjusted R Square	0.629764065
Standard Error	0.80860754
Observations	13

TABLE 6. Regression Analysis for Part 1-2 against Part 1-3 for Jan 2022

Regression Statistics	
Multiple R	0.683763459
R Square	0.467532468
Adjusted R Square	0.419126328
Standard Error	0.823216831
Observations	13

In order to validate the results in January 2022 cohort, another regression analysis was done to find the relationship between formative assessment 1-1 versus 1-2 and formative assessment 1-2 versus 1-3 for Aug 2022 cohort IPP framework. The regression model shows that the relationship is linear as can be observed in Table 7 and 8. It could also be observed that from the Pearson Regression (Multiple R) value of 0.78 and 0.70 are much above 0.5, that shows that all three formative assessments have a positive relationship with each other. Furthermore, the R Square value shows that 61% of the variation and 50% of the variation lies around the mean. This supports the correlation results and it reflects a strong relationship between each formative assessment.

TABLE 7. Regression Analysis for Part 1-1 against Part 1-2 for Aug 2021

Regression Statistics	
Multiple R	0.683763459
R Square	0.467532468
Adjusted R Square	0.419126328
Standard Error	0.823216831
Observations	13

TABLE 8. Regression Analysis for Part 1-2 against Part 1-3 for Aug 2021

Regression Statistics	
Multiple R	0.707715663
R Square	0.50086146
Adjusted R Square	0.483035084
Standard Error	0.752222639
Observations	30

Analysis of Variance – ANOVA

In order to determine if the correlation between each assessment for the IPP framework is statistically significant, the p-value needs to be below alpha value, 0.05. Referring to Table 9 and 10, since both the p-values for each assessment in Jan 2022 (highlighted in yellow) shows lower than 0.05, the correlation between the Part 1-1 to Part 1-2 assessment and Part 1-2 to Part 1-3 assessment is statistically significant.

TABLE 9. Significant P-value Between Part 1-1 to Part 1-2 Assessment for Jan 2022

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	14	14	21.41176471	0.000731636
Residual	11	7.192307692	0.6538462		
Total	12	21.19230769			

TABLE 10. Significant P-value Between Part 1-2 to Part 1-3 Assessment for Jan 2022

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6.545455	6.545455	9.658536585	0.009964167
Residual	11	7.454545	0.677686		
Total	12	14			

To further validate the significant value of the IPP assessments framework for Jan 2022 semester, the p-value needs to be below alpha value, 0.05. Referring to Table 11 and 12 below, since both the p-values highlighted in yellow for each assessment in Aug 2022 (highlighted in yellow) also shows lower than 0.05, the correlation between the Part 1-1 to Part 1-2 assessment and Part 1-2 to Part 1-3 assessment is validated to be statistically significant.

TABLE 11. Significant P-value Between Part 1-1 to Part 1-2 Assessment for Aug 2021

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12.19657	12.19657	43.95107437	3.42296E-07
Residual	28	7.770095	0.277503		
Total	29	19.96667			

TABLE 12. Significant P-value Between Part 1-2 to Part 1-3 Assessment for Aug 2021

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	15.89818	15.89818	28.09665007	1.21975E-05
Residual	28	15.84349	0.565839		
Total	29	31.74167			

From the data of regression and p-values, it could be concluded that there is a significant positive relationship between each of the formative assessment being conducted. The strong relationship suggests that the progressive work of the students was built upon from one assessment to the other, to the point that have improved their performance in the course outcome.

CONCLUSION

From the observations of this comparative case study, it clearly shows that the students who went through the IPP framework has a positive effect in the students learning and performance. Both cohorts were attributed against the same constraints in their project in terms of time, and available resources and working in groups. Both applied the IPP framework throughout their formative assessments using real world projects. Although there may have many other factors that could contribute to the different results, such as the level of difficulty of the case studies in different cohorts, or that the cohort of class size were inconsistent, and different cohorts may have undergone a different prior project experience, the overall results display very similar assessment results. Evidently, both semester outcomes supported the same results from the statistical analysis. The correlation of data and the regression analysis reflects very similar characteristics. The IPP framework proves to provide a better learning experience with real world experience and reflection. The cognitivist and constructivist learning theory proves to be applicable and beneficial to students learning. It was observed that the students seem to be better prepared through their IPP formative learning and would eventually reflect higher achievement in the programme outcome. In addition, the IPP framework do have some disadvantages, such as it requires higher frequency of assessment and feedback by the instructor in the preparation of course material. Nevertheless, the outcome does show a greater impact with positive improvement in the affective and cognitive domain of the learners. This is the essence of student centred learning ensuring where the learners are capable to be life-long learners and at the same time be able to handle or face complex problem solving as prescribed in the OBE framework emphasized by the Board of Engineers Malaysia.

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