Attitudes and Academic Performance of Engineering Students in both Prerequisite Courses to Final Year Project and Final Year Project

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Abstract

The aim of this study was to examine the attitudes of engineering students and their academic performance towards both prerequisite courses for and the final year project (FYP), given the need to increase our understanding of attitudes and performance in the context of engineering students, currently underexplored. Questionnaire surveys of 714 eligible students enrolled in the FYP across six engineering programs were conducted. The results show that students enrolled in Industrial, Mechanical and Civil engineering programs, have a negative attitude towards the FYP and its prerequisites, while students enrolled in Electrical, Electronic and Industrial Design and Technology programs have a positive attitude. A statistically strong positive correlation between project prerequisites and engineering FYP was found, confirmed by factor analysis. Majority of students struggle with project progress as compared to other stages of the FYP, due to inadequacy in fundamentals such as design. This study contributes to an understanding of existing knowledge by providing empirical evidence of not only challenges faced by engineering students (as opposed to other disciplines that have been widely covered) but also remedies to improve students' academic performance. The findings also have implications on engineering education, in relation to informing policy decisions on engineering program structure.

Keywords: grades, higher education, capstone projects, attitudes

1. Introduction

One of the crucial factors determining students' success is their attitude. Students' attitudes at various stages of learning can have an impact on their academic performance (Agoestina et al., 2022; Alanzi, 2015; Ali et al., 2009; Artal-Sevil et al., 2015; Bandele and Adebule, 2013), since attitude influences how students learn, study and participate in class. There are three modes of attitude namely: behavioral, affective and psychological. These modes can further be classified into two types of attitude namely: positive and negative. The way a university student's emotions are towards a topic is referred to as affective attitude. Positive attitudes lead students to positive behaviors towards their course of study in relation to active participation. Conversely, negative attitudes have a negative impact on a student's conduct towards a specific subject. Many university students do not realize the value and importance of project prerequisites to their learning. Some students believe that project prerequisites are unimportant and unnecessary. Negative attitude results in a lack of desire and interest in a certain subject (Ali et al., 2009).

Prerequisites are meant to ensure that students have some prior knowledge before enrolling in a subsequent course. These prerequisites not only make students feel more at ease and confident about the subsequent course but also make students perform academically better. Excellent grades in prerequisites usually result in good performance in a subsequent course, whereas poor performance in prerequisites usually leads to poor performance in the subsequent course (Bayaga and Wadesango, 2014). The final year project has been defined as one of the essentials in existence, for an undergraduate engineering student. The final year project offers students the right abilities to exercise expert engineering knowledge through imparting them with an opportunity to work on an engineering problem. Typically, students would apply knowledge they learnt from different introductory courses to their final year project. Introductory courses to the final year project are based on the program structure for each engineering program and informed by specific disciplines and/or majors, in relation to the need to address relevant trends associated with industry needs. These introductory courses are compulsory components of each respective Bachelor of Engineering curriculum (Departmental Final Year Project Committee, 2020; Department of Public Affairs, 2023).

The structure of the final year project is divided into two; project 1 and project 2. Students can only be allowed to enroll into the final year project after passing all prerequisite courses to project 1. These prerequisites are selected from majority of courses undertaken by students as per program curriculum. The final year engineering project is aimed at enabling students the opportunity to demonstrate what they have learnt over the duration of their engineering program, normally five years. Using the department of Mechanical Engineering that offers two programs namely: Bachelor of Mechanical Engineering and Bachelor of Industrial Engineering, the final year project for each of these two programs comprises project 1 and project 2. For Mechanical Engineering program, project 1 is denoted by the course code MMB 511 (5 indicating year 5 or level 500) whilst project 2 is denoted by the course code MMB 521. Similarly, for Industrial Engineering program, project 1 is denoted by the course code IMB 511 whilst project 2 is denoted by the course code IMB 521. The course codes MMB and IMB depict mechanical and industrial engineering programs respectively. The two final year project courses (project 1 and project 2) from each program are offered in year 5 (level 500) of semesters 9 and 10. These courses comprise three hours of practical work per week and constitute 6 credits each. The total credits from both project 1 and project 2 is 12, whilst majority of the introductory courses and/or prerequisites to the final year project have a total of 3 credits each (Departmental Final Year Project Committee, 2020).

Prerequisite courses to the final year project are relevant and essentially requirements to registering for a final year engineering project. For example, project 1 under industrial engineering program (IMB 511) has 6 prerequisites namely: (1) IMB 324 Productivity and Technology Management, (2) IMB 413 Simulation Modelling, (3) IMB 423 Process Planning and Cost Estimation, (4) IMB 424 Industrial Quality Control, (5) IMB 513 Industrial Relations, and (6) IMB 515 Operations Research II, whose prerequisite is IMB 425 Operations Research I (Department of Public Affairs, 2023). These prerequisites are intended to equip students with practical experience relating to some aspect of industrial or mechanical engineering such as cost, design, operations management, all of which are relevant in enabling an engineering student to tackle final year project activities (Departmental Final Year Project Committee, 2020). Exploring relationship between final year project and its prerequisite is key to uncover contradictory opinions about the importance of prerequisites (Alanzi, 2015; Bayaga and Wadesango, 2014; Carnduff and Reid, 2003; Christensen et al., 2012).

1.1 Gap and Study Motivations

Declining graduation numbers and poor academic achievement of engineering students has become a major concern in universities (López et al., 2020; Jove et al., 2018). Existing research conducted on students at higher education institutions (universities) have indicated that there is a link between student attitudes and academic achievement, primarily in the education domains of business, finance, accounting, arithmetic, linguistics, English, and communication (Ali et al., 2009; Bhowmik and Banerjee, 2012; Boyd et al., 2000; Brasfield et al., 1992; Caballero et al., 2007; Cheung and Kan, 2002; Christensen et al., 2012; Didia and Hasnat, 1998; Fakeye, 2010; López et al., 2020; Jove et al., 2018). Little is known about the relationship between attitudes of engineering students and its effect on academic performance, which could possibly be the cause of declining academic performance and huge gender gaps in the field of engineering. In response to this gap, this study intends to contribute to an understanding of not only the issues surrounding attitudes and academic performance of engineering students towards the final year project, but also uncovering the challenges and potential solutions to enhance students' academic performance.

Moreover, existing studies have focused predominantly on quantitative approaches that use Likert scales to measure students' attitudes, resulting in a need for an in-depth study that applies engineering lean tools to capture complete experiences of students, including their challenges with an engineering final year project in a specific context. The need to supplement engineering student experiences with quantitative and qualitative data is deemed to offer a full and wide-ranging understanding of not only their attitude and academic performance on both final year project pre-requisites and final year project, but also remedies for improving engineering students' learning processes. Given this identified literature gap, the current study applies a lean manufacturing tool called DMAIC (Sokovic et al., 2010) to contribute to a deeper understanding of engineering students' attitudes and academic performance on final year project related courses.

1.2 Aim, Objectives and Research Questions

This study aimed to examine the attitudes of engineering students and their academic performance on both final year project prerequisites and final year project. The research objectives were: (1) to determine which stage of the final year project students struggle the most and why, (2) to measure the attitude of engineering students towards prerequisite courses to the final year project and the final year project, (3) to explore the relationship between attitude and academic performance on both project prerequisites and final year project.

1.2.1 Research Questions

The research was guided by the following questions, derived from propositions informed by education literature.

Research Question 1 (RQ1).What is the attitude of engineering students towards final year project and its prerequisites?

Research Question 2 (RQ2). Is there a difference between the attitudes of male and female students?

Research Question 3 (RQ3). Is there a relationship between attitude and academic performance on both prerequisites and the final year project?

Research Question 4 (RQ4). What factors affect academic performance of students during the final year project?

1.2.2 Hypotheses

The following hypotheses were constructed:

H1 - Negative attitude leads to poor academic performance (null hypothesis, denoted by H_0). It follows that the alternative hypothesis (denoted by H_1) is that positive attitude leads to good academic performance (Agoestina et al., 2022; Bayaga and Wadesango, 2014; Bhowmik and Banerjee, 2012; Caballero et al., 2007).

H2 - There is no significant difference in the attitude of students in various engineering programs (Brasfield et al., 1992).

H3 - There is no significant difference between the attitude of male and female students towards final year project and its prerequisites in engineering programs.

H4 - Academic performance in prerequisite courses to the final year project is correlated with academic performance in the final year project. The proposition to this hypothesis is that there is no correlation between academic performance of students in final year project prerequisites and their academic performance in the final year project (Alanzi, 2015; Christensen et al., 2012; Huang et al., 2005).

The associations being explored in this study are: (1) attitude and academic performance on final year project prerequisites, and (2) attitude and academic performance on the final year project.

1.3 Scope

This study was confined to one faculty (Faculty of Engineering and Technology) within one large university and specifically four departments namely: Mechanical engineering, Civil engineering, Electrical engineering and Industrial Design and Technology. The study was confined to 6 specific engineering programs, which were: industrial engineering (comprising 6 project prerequisites), mechanical engineering (comprising 5 project prerequisites), civil engineering (comprising 1 project pre-requisite), electrical engineering (comprising 4 project pre-requisite), electronic engineering (comprising 2 project pre-requisite) and industrial design and technology (comprising 2 project prerequisites). The informants were full-time undergraduate engineering degree students enrolled in the final year project within the stipulated programs.

2. Literature Review

2.1 Attitude

The attitude of students at different levels of education influences many factors, including how and what they learn (Bandele and Adebule, 2013; Bhowmik and Banerjee, 2012). Attitudes are vital to us due to the fact that they cannot be smartly separated from studying. Following a critical review of studies on attitude of students towards mathematics, english and literature, educational research writing, linguistics, and essay writing (Ali et al., 2009; Bhowmik and Banerjee, 2012; Boyd et al., 2000; Brasfield et al., 1992; Caballero et al., 2007; Christensen et al., 2012; Didia and Hasnat, 1998; Fakeye, 2010; López et al., 2020; Jove et al., 2018), several authors are unified in revealing that positive attitude leads to good performance while negative attitude leads to poor performance.

2.1.1 Dimensions of Attitude

There are 3 dimensions of attitude, which are: affective, behavioral and cognitive/psychology (Bishara and Hittner, 2015; Chaiklin et al., 2011; Fakeye, 2010). Affective attitude deals with the way a person`s emotions or feelings are towards a topic or item. Behavioral attitude deals with how attitude affects the way we act or behave. Cognitive attitude deals with expressions of believes and thoughts about an object or item.

2.1.2 Attitude Measurement Scales

Self-rating scales are used to assess a person's attitude, using a self-assessment of the person’s own qualities (Carvalho and White, 1997). Attitude can be measured by implementing rating scales in different data collection tools such as questionnaires (Chaiklin et al., 2011). Some of the frequently used scales to measure attitude include Likert scales and Ordinal scales. In a Likert scale, respondents are asked to rate their level of agreement and disagreement with a series of statements. There are five response categories for each scale item, ranging from strongly agree to strongly disagree (Cheung et al., 2002; Joshi et al., 2015). Ordinal scales are used particularly when ranking order is important. These scales are used to determine how important specific benefits are to the respondents (Carvalho and White, 1997).

2.2 Academic Performance

Academic performance is a student's ability to achieve the aims, achievements, and objectives set forth in the program or course that a student is enrolled (Carnduff and Reid, 2003). There is a positive correlation between prerequisite grades and students' overall performance. In the accounting discipline, students who passed a prerequisite had considerably better grades in the preceding courses of accounting (Huang et al., 2005). In the field of finance, it was found that having a math prerequisite improved students' performance in finance classes (Didia and Hasnat, 1998). Students' success in introductory accounting subjects had a high positive association with their performance in Financial Management. Alanzi (2015) also offered reasonable proof for the organization of international accounting education that prerequisites are important. In the allied discipline of economics, mathematical prerequisites should be implemented as soon as possible because their findings revealed a strong correlation between performance in calculus courses and performance in intermediate microeconomics (Von Allmen, 1996). In a study of students' performance in learning communication course, it was simpler for students to understand the theories and concepts presented in an advanced subject after passing the preliminary communication subject (Cheung et al., 2002).

Similar research, however, have yielded contradictory outcomes. For example, Christensen et al. (2012) investigated whether undergraduate prerequisite courses predicted MBA success. Results revealed students who lacked business prerequisite courses performed better in MBA grade point average than students who took prerequisites. Other researchers have also concluded that prerequisites are not important in the accounting discipline (Tureysky et al., 2003). For example, grasping the concepts is more important than passing the requirement. Similarly, Brasfield et al. (1992) rendered prerequisites to be unimportant and slowed the learning process in accounting. Christensen et al. (2012) expands on this idea of pre-requisites and provides additional factors that could make prerequisite less effective and unnecessary.

2.3 Six Sigma and Student Performance Improvement

Based on case studies, positive findings were revealed, indicating that Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology can be utilized to directly affect student performance (Dhariwal and Bhagchandani, 2013; Hargrove and Burge, 2002; Prasad et al., 2012; Zahn et al., 2003). Hargrove and Burge (2002) also proved this theory by applying Six Sigma DMAIC approach to boost minority student retention rates in order to meet the industry's demand for highly qualified workers. Introducing a Six Sigma DMAIC methodology to students in a statistics classroom might boost their involvement and knowledge (Dhariwal and Bhagchandani, 2013).

2.4 Literature Review Summary

A summary of relevant literature is depicted in Table 1 and Table 2. Since the current study explores 2 main variables namely attitude and academic performance, Table 1 summarizes relevant studies on attitudes of students while Table 2 summarizes studies conducted on academic performance of students.

Table 1. Summary of studies conducted on attitude

Title	Reference	Key research questions	Identified gaps
Students' attitude towards English and literature.	(Fakeye, (2010).	Does attitude affect the effectiveness of students learning English and literature?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project.
Students' attitude towards learning mathematics.	(Bayaga and Wadesango, 2014).	Is there a relationship between attitudes of students and learning mathematics?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project.
Students' attitude to learning mathematics.	(Bhowmik and Banerjee, 2012; Jie, 2020).	What is the effect of attitude towards learning mathematics?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project.
Attitudes towards Learning.	(Caballero et al., 2007; Kara, 2009).	Is there a relationship between students' attitudes and learning?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project
The relationship between Self-efficacy in reading and in writing and undergraduate students' performance in English literature.	(Wanchid and Wattanasin, 2015).	How does attitude affect performance of undergraduate students' studying English literature?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project.
Attitudes, Behavior and Social Practice	(Prat-Sala and Redford, 2012).	Is there a relationship between Attitudes, Behavior and Social Practice?	How attitude of engineering students' affects their performance in prerequisites and Final Year Project.

Table 2. Summary of studies conducted on academic performance

Title	Reference	Key focus area	Identified gaps
How performance in prerequisites course affect performance in the preceding course accounting.	(Boyd et al., 2000).	Effect of attitude on the performance of accounting students.	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.
How performance in prerequisites course affect performance in the preceding course accounting.	(Huang et al., 2005; Tureysky et al., 2003).	Factors that led to poor academic performance in accounting.	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.
How performance in prerequisites course affect performance in the preceding course to communication course.	(Cheung et al., 2002).	Impact of cumulative GPA on students' performance in prerequisite and the preceding course in communication?	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.
Principles of technology integration.	(Liu, 2005).	Attitude towards technology integration in education and its impact on academic performance.	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.
Whether undergraduate prerequisite courses predicted MBA success.	(Christensen et al., 2012).	Investigating whether cumulative GPA and prerequisite predicted success in MBA.	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.
How performance in Principles of Accounting I affect performance in Principles of Accounting II.	(Huang, et al., 2005).	Does the type of program a student is enrolled in have an impact on their accounting performance?	How performance of engineering students' in prerequisites courses affect their performance in the Final Year Project.

The Affective-Cognitive Consistency Theory, which postulates that changes in an individual's affective component will result in changes in their cognitive component (Rachmatullah and Ha, 2018), was the foundation theory for this research. Conclusive literature from Tables 1 and 2 indicated that students' attitudes regarding a subject have an impact on how well they do on it. A student who has a poor attitude about a subject will believe that he or she will struggle with it. However, a student who has a positive outlook on a subject will be motivated to do well because they believe they can succeed in that area. Tables 1 and 2 provide a theoretical foundation that was ultimately used for a deeper understanding of the research topic, on the basis of examining another education domain (Engineering), other than existing education domains in extant literature. Therefore, the approach in this study enabled relevant and new understanding to existing knowledge, including implications for both policy and practice, on the basis of new understanding.

2.5 Research Variables and Measures

Given the discussions in section 1.2 and this literature review section, five key research variables (RVs) were identified for this study. These five key research variables are divided into two main groups namely: attitude variables and academic performance variables. The attitude variables are: (1) behavioral (RV1), (2) affective (RV2), and (3) psychological (RV 3). The academic performance variables are: (4) academic performance on prerequisites (RV4), and (5) academic performance on final year project (RV5). These five research variables and their measures to address the two main research objectives, are depicted in Table 3.

Table 3. Objectives, Research Variables and Measurements

Objectives	Research Variables and Measures	Variable Type
1. To measure the attitude of engineering students towards final year project prerequisites.	1. Behavioral attitude (RV1). 1.1 Lack of contact and assistance from project supervisor affected my performance negatively. 1.2 Skipping final year project prerequisite classes affected my performance negatively.	Independent.
	2. Affective attitude (RV2). 2.1 My attitude towards Final Year Project prerequisites made me perform poorly in them. 2.2 Not liking Final Year Project prerequisite lectures affected my performance negatively.	Independent.
	3. Psychological/cognitive attitude (RV3). 3.1 Project prerequisites are not important. 3.2 Only brilliant students can pass project prerequisite with high grades. 3.3 Final Year Project will not be important to me in the future.	Independent.
2. To explore the relationship between attitude and academic performance on both project prerequisites and final year project.	4. Academic performance on project prerequisites (RV4). 4.1 Overall score on pre-requisite course for industrial engineering. 4.2 Overall score on pre-requisite course for mechanical engineering. 4.3 Overall score on pre-requisite course for civil engineering. 4.4 Overall score on pre-requisite course for industrial design and technology.	Dependent.
	5. Academic performance on final year project (RV5). 5.1 Overall score on industrial engineering final year project. 5.2 Overall score on mechanical engineering final year project. 5.3 Overall score on civil engineering final year project. 5.4 Overall score on industrial design and technology final year project.	Dependent.

3. Methodology

A mixed-methods approach was chosen, given that the three objectives in this study examined diverse characteristics associated with an undergraduate engineering final year project which had two types of data; quantitative and qualitative. The first and second research question required quantitative data to capture descriptive statistics concerning attitude of engineering students measured under 3 dimesions (cognitive, affective and behavioral attitude).The third research question required both quantitative and qualitative data to explore the association between attitude and academic performance on both prerequisites and the final year project. The fourth and last research question required qualititatve data to identify challenges affecting engineering students during the final year project and the reasons behind those challenges. Analysis of responses to these questions formed the basis to describing the attitude and academic performance of engineering students in prerequisite courses and the final year project, using an overall mixed methods approach (Bazeley, 2009; Creswell and Clark, 2011; Greene, 2007; DeCuir-Gunby, 2008; Jick, 1979).

The importance of applying this approach, in terms of collecting both quantitative and qualitative data will lead to discovering new insights and/or deeper understanding of the issues concerning attitudes and academic performance, which may not be possible from either the quantitative or qualitative data on its own (Bazeley, 2009; Creswell and

Clark, 2011; Greene, 2007; Jick, 1979). This mixed methods approach provides a better opportunity to address the overall research aim, decomposed into objectives and questions (Creswell and Clark, 2011; Cohen et al., 2011; Teddlie and Tashakkori, 2003; DeCuir-Gunby, 2008; Ivankova and Creswell, 2009).

A pragmatist philosophical perspective was appropriate and used to inform the chosen mixed methods research approach, given the need to completely accomplish the research objectives and questions indicated in section 1.2 (Glaser and Strauss, 1967; Greene and Caracelli, 1997). A semi-structured questionnaire survey was developed and used to collect data from engineering students enrolled in six different programs. The data sought focused on two key research variables namely: attitudes (behavioral, affective, and psychological) and academic performance (i.e., performance on pre-requisites to final year project and performance on final year project) of engineering students. The inclusion of all six groups of engineering students was necessitated by the need to have a balanced faculty perspective on attitude and its relationship with academic performance. The six groups of engineering students within the faculty of engineering and technology denote different data sources, in the context of a research design to address measurement error or common method variance (Fellows and Liu, 2003; Freund et al., 2006; Gray and Kinnear, 2012).

Moreover, additional approaches used in this study to address common method variance (Podsakoff et al., 2003) before data collection included: (1) carefully deriving item measures for observed variables, justified by relevant literature in terms of theoretically linking the items to key research variables, and (2) pilot testing of the questionnaire survey. Post data collection, three additional approaches were employed to address the issue of common method bias namely: (1) Reliability analysis in relation to Cronbach alpha coefficients for all datasets, (2) Harman's method (single factor test), and (3) Factor analysis (principal component analysis). On this basis, multiple statistical analyses were conducted, categorized into two groups namely: (1) those associated with remedies to address reliability of research instruments on the basis of both the context and sources of measurements, as part of the research design, and (2) those that address research objectives and questions described in section 1.2.

3.1 Development of the Research Instrument and Research Design

A semi-structured questionnaire was developed, informed by existing literature (Agoestina et al., 2022; Bauer et al., 2020; Bhowmik and Banerjee, 2012; Bishara and Hittner, 2015; Brewer and Hunter, 2006; Caballero et al., 2007). A total of 14 items were used to measure attitude and performance of students enrolled in different engineering programs. The research instrument consisted of three parts. The first part comprised of items used to capture descriptive statistics about the respondents. The second part consisted of closed ended questions, where the respondents were asked to indicate their level of agreement with a series of statement concerning engineering students' attitudes. A 1 to 5 Likert scale was used, where 1 = strongly agree and 5 = strongly disagree. The third part of the questionnaire contained opened ended questions where the respondents were allowed to explain their attitudes towards pre-requisite courses to the final year project.

Participant information sheets, as well as participant consent forms, were provided to informants, with a view to assure informants of both anonymity and confidentiality. The purpose was to encourage more honest responses pertaining to attitudes and academic performance. Consent forms also contained details to highlight the need for honest responses and that there are no wrong or right responses. Over and above the design relating to context and sources of measurements, additional remedies were employed to address common method bias through careful derivation of item measurements for attitude (Podsakoff et al., 2003). These remedies included: (1) avoiding complex question wording, (2) avoiding compound questions that contain more than two distinct aspects, and (3) defining attitude terms that informants may consider to be unclear. Two procedures proved valuable in addressing the above 3 remedies namely: (1) rigorous ethical review process that afforded an initial opportunity to address measurement error, and (2) pilot testing of the research instruments to address measurement error that has potential to affect questionnaire surveys, due to lack of the prospect to clarify seemingly unclear questions (Gray and Kinnear, 2012; Greene, 2007; Greene and Caracelli, 1997).

3.2 Data Collection and Sampling Methods

A semi-structured questionnaire was used to measure attitude and academic performance of students in both final year project and project prerequisites and contained both quantitative and qualitative questions pertaining to three major themes that were informed by the literature guiding the research aim, objectives and questions discussed in section 1.2. These themes were: (1) attitudes of engineering students, (2) relationship between engineering students' attitude and their academic performance on final year project prerequisites, and (3) relationship between engineering students' attitude and their academic performance on the final year project. In the context of quantitative data, the questionnaire employed a 5 point Likert Scale, where 1 = strongly agree and 5 = strongly disagree (Joshi et al., 2015). The questionnaire also included open ended questions that explored the same three themes, with a view to provide a complete description of the phenomenon being studied, from the perspective of combining analysis of both data types. These themes are linked and supported by the data collected. For example, data on engineering students' attitudes, data on engineering students' academic performance in final year project prerequisites, data on engineering students' academic performance in the final year project. A total of 14 items were used for measuring attitude and academic performance.

The following data sampling methods were considered for this study: simple random sampling, systematic sampling, cluster sampling, purposive sampling, snowball sampling and enumeration (Berndt, 2020; Etikan and Bala, 2017; Taherdoost, 2016). Enumeration was chosen over other sampling methods given the nature of the population of eligible informants (i.e., engineering students enrolled in the final year project each semester), in the context of a relatively small number of final year project students. However, given the practical challenges of access to data (Gray and Kinnear, 2012; Greene, 2007; Greene and Caracelli, 1997), data was collected from a total of 714 students for a period of 3 academic years (2017, 2018 and 2019). Reliability issues were addressed through the use of the same questionnaire comprising precisely the same questions and administered in a consistent manner to all informants. Data regarding academic performance of students was obtained from Faculty of Engineering administration office, in compliance with completed research ethics procedures. Participant consent forms were used in combination with the questionnaire survey, to collect primary data about attitudes of engineering students.

3.3 Data Analysis

Mann Whitney U test, Pearson correlation, factor analysis and Bayesian correlation were used to determine the attitude of engineering students and its relationship on academic performance, to answer research question 1 (Fellows and Liu, 2003; Freund et al., 2006; Gorsuch, 2021; Kervin, 1992; McKnight and Najab, 2010; Waldmann, 2019). Regression analysis was used to analyze qualitative data in response to research questions 2 and 3 (Freund et al., 2006). Framework method (Gale et al., 2013) and thematic analysis (Braun and Clarke, 2006). were used to analyze qualitative data in response to research question 4, with a view to uncover challenges affecting engineering students during the final year project. Harman's single factor test was used to test for Common method biases in the research instrument (Gorsuch, 2021, Podsakoff et al., 2003).

3.3.1 Analysis of Quantitative Data

Regression analysis was used to test for correlation between final year project and its prerequisites. Prerequisites were assigned to be x variables in the (y, x) coordinate system and used to determine how a change in the x variable influenced a change in the y variable (the final year project). An F test was then used to test for statistical significance, at 95% confidence interval. Descriptive statistics were used to summarize academic performance of students in project prerequisites and final year project. Factor analysis concepts (Fabrigar et al., 1999; Gorsuch, 2021). were ultimately used for research reliability, in the context of additional and more robust analysis of quantitative data. For example, Cronbach alpha was used to test for reliability analysis of attitude results obtained through the questionnaire. Harman's single factor test was used to test for Common method biases in the research instrument. Barletts' Test, along with Kaiser-Meyer-Olkin (KMO) test, were used as part of additional methodologies involving factor analysis, to determine the extent to which the scale used in the study is reliable (Kervin, 1992). Pearson correlation was used to test for the relationship between attitude and academic performance of students. Bayesian correlation factor was then used to determine the strength of the correlation between the two variables; attitude and academic performance (Waldmann, 2019; Dienes, 2021; Matzke et al., 2017; Schönbrodt and Wagenmakers, 2018). Mann Whitney U-Test (McKnight and Najab, 2010) was used to explore the statistical significance of the difference between male and female students enrolled in different engineering programs, in relation to three attitude variables (behavioral, affective and psychological). Justification for using a Mann Whitney U test instead of an independent samples t-test lies in the following: (1) the fact that the data were non-parametric and hence did not meet parametric assumptions of both normality and homogeneity of variance, and (2) the relatively small sample of final year project students. The intent was to establish whether the difference, if statistically significant, between the attitude of male and female engineering students is not due to random causes. Principal components analysis, using Varimax rotation, was performed to determine the construct validity of the scale.

3.3.2 Analysis of Qualitative Data

'Framework method' was considered appropriate for managing and reducing the volume of data from an in-depth study of attitudes and academic performance of engineering students towards both final year project prerequisites and the final year project. The rationale for choosing 'Framework method' over alternative techniques was based on flexibility to be used with many qualitative data analysis approaches that seek to generate themes, without worrying about which philosophical perspective underpins the adopted approach or which particular discipline is aligned with that approach (Gale et al., 2013). For example, whilst alternative qualitative approaches such as Grounded Theory (Glaser and Strauss, 1967) are concerned specifically with generation of theory (inductive) in the context of say thematic analysis, 'Framework method' is flexible for use with an inductive thematic analysis and a deductive thematic analysis, or a combined approach. Content and thematic analysis were used to explore dominant themes relating to which stage of the final year project engineering students struggle with and why (Braun and Clarke, 2006; Bryman, 2008; Miles and Huberman, 1984). Justification for using content and thematic analysis lies in the intent to derive not only meanings and explanations but also rich descriptions about engineering students' attitudes towards both final year project prerequisites and the final year project, particularly from a mass of data concerning divergent views (Busha and Harter, 1980; Krippendorf, 2004) of engineering students enrolled in different programs. This analysis was followed by interpretation of dominant themes.

3.4 Procedures for Integrating Analysis of both Quantitative and Qualitative Data

Following separate analyses of each type of data, the results of each analysis were combined for additional analysis, on the basis of factors relevant to uncovering a comprehensive description of engineering students' attitudes and academic performance. For combining these forms of data, a number of analytical techniques were investigated. All three analytic strategies proposed in (Bazeley, 2009; Brewer and Hunter, 2006; Creswell and Clark, 2011; Greene, 2007) were explored namely: (1) creating a matrix to facilitate comparison of the quantitative results with the qualitative results, (2) transforming the results of either the quantitative or qualitative data type into the other data type, and (3) integrating the quantitative and qualitative data in terms of a combined analysis. The first two strategies were discarded on the basis that the intent was not to compare the two data types but rather to uncover a complete understanding of the attitudes and academic performance of engineering students. It follows that the third analytic strategy was adopted on the basis of its usefulness to generate new insights that fully addressed the study objectives.

3.5 Research Validity and Reliability Criteria Development

An overview of evaluating research quality in connection to the quantitative-qualitative dichotomy is appropriate, given that research reliability and validity are linked to an assessment of research quality (Bringer, 2002; Lincoln and Guba, 2000). Table 4 demonstrates quality in the analysis of both the quantitative and qualitative data for this study.

Table 4. Validity and Reliability criteria development for both quantitative and qualitative data

Quantitative criteria	Qualitative criteria	Method for achieving qualitative criteria
External validity.	Transferability.	Detailed description of research processes and procedures.
Reliability.	Dependability/replicability/consistency.	Same questionnaire offered and treated the same to all informants.
Reliability.	Dependability /trustworthiness.	Explicit statement of assumptions and acknowledgment of limitations.
Internal validity.	Credibility.	Analysis of whole data for recurrent themes using thematic analysis.
Reliability.	Dependability.	Employing triangulation and sampling decisions.

4. Results and Discussion

The results are presented in terms of the following: Common method bias, problems facing students at different stages of the final year project (objective 1), attitude and academic performance on both project prerequisites and final year project (objective 2), relationships between academic performance of students in project prerequisites and final year project (objective 3).

4.1 Common Method Bias

Following Harman's single factor test to address common method bias as part of demonstrating the reliability of collected data as described in the methodology section, the results show that 33% (which is below 50 %) of the total variance is explained by the data. These results indicate that the data obtained from the questionnaire are statistically significant and were not affected by common method bias (Prion and Adamson, 2013; Podsakoff et al., 2003).

4.2 Problems Facing Students at Different Stages of the Final Year Project (Objective 1)

Failure modes and effect analysis (FMEA) presented in Table 5 shows an analysis of problems affecting engineering students during the final year project. Table 5 depicts a thematic analysis of themes associated with problems affecting engineering students during the final year project.

Table 5. Failure Modes and Effects Analysis of Problems affecting Students during the Final Year Project

Problem		Potential Failure Mode	Potential Effect on student	Potential Causes	Current Process Controls	Actions Recommended	Responsible and Target
Poor Design and manufacturing of the final product.	Poor performance in project prerequisite.	Failing or poor performance in FYP.	Negative attitude towards FYP and FYP prerequisite. Poor performance in FYP Prerequisites.	Optional course offered to improve skills.	Students must take project prerequisite courses seriously. Take advantage of optional courses to improve their design and manufacturing skills.	students	
Poor research skills.	Lack of basic concepts and understanding on how to conduct a research.	poor performance in FYP	Lack of practice in preparing literature review. Negative attitude towards learning.	Mini projects.	Industrial design and technology, along with civil engineering department, should introduce mini projects in their programs.	Student and faculty administration	Poor research skills.
Delayed Procurement of materials by students.	Poor project management skills, Lack of funds.	Delayed manufacturing process of FYP.	Poor performance in project management courses. Have not pursued courses related to project management.	Offering project management as an optional course.	Offer project management as a core course instead of an optional course in the current curriculum, and make it a pre-requisite to the final year project (Project I).	Faculty administration	
Lack of team work.	Communication skills.	Slow progress in FYP leading to poor performance.	Poor interpersonal and leadership skills.	Mini projects and communication courses.	Civil engineering and industrial design and Technology should introduce both communication skills courses and mini projects (project work)	Student and faculty administration	

					in their respective programs. Students should work on their interpersonal skills and be tested in terms of exist level outcomes that must be built into assessments.		
Language barrier.	Poor communication and interactions between students and lab technicians.	Poor understanding of engineering concepts by students.	Poor performance in project prerequisites.	Optional course to improve engineering skills.	Develop positive attitude towards learning.	Students	
Emotional distress.	Failure in completing the course.	Lose of interest.	Family and Peer pressure, performance anxiety.	Free and professional counselling is offered to university students within the institute.	Counselling.	Students	Emotional distress.

Table 5 was employed as an analytical tool to comprehend the issues affecting students in terms of their prospective sources, effects on the students, and prevention strategies currently in place. The table then offers recommendations to address identified challenges, with a view to improve students' academic performance.

Table 6. Thematic Analysis of Problems facing Engineering students

Problems affecting students	Mechanical department	Industrial Design and Technology	Civil engineering	Total	Project proposal	Project progress 1	Project progress 2
Procurement of project materials by students.	10	7	5	22	0	4	18
Preparing literature review.	12	17	19	48	27	16	5
Lack of FYP funds.	19	22	22	63	16	22	25
Data collection from companies.	8	14	19	41	0	23	18
Designing and manufacturing the final product.	10	11	2	23	0	0	23
Poor presentation skills.	19	12	17	48	19	17	12
Lack of team work.	13	10	0	23	0	9	14
Communication barrier between students and lab technicians.	11	13	4	28	0	10	18
Totals	102	96	88	296	62	101	133

Table 6 contains results of thematic analysis. The numbers within the cells indicate the frequency with which a particular theme has been mentioned by the respondents. The results reveal that lack of FYP funds is a dominant theme that affects students during the final year project, followed by preparing literature reviews, poor presentation skills, and data collection from companies. Thematic analysis has also identified project progress 2 as the most challenging stage of the final year project, followed by project progress 1, then project proposal. This is based on the number of problems encountered by students at each stage of FYP. Most of the problems were caused by poor project management skills, poor performance in project prerequisites, and poor research skills, as indicated by Table 5.

4.3 Attitude and Academic Performance on both Project Prerequisites and Final Year Project (Objective 2)

The results pertaining to attitude of engineering students towards prerequisite courses to the final year project and the final year project are presented in the context of three items: (1) reliability analysis, (2) factor analysis and (3). Mann Whitney U-test.

4.3.1 Reliability Analysis

Reliability analysis pertaining to the attitude variables was performed for engineering students enrolled in four engineering departments.

Using Cognitive/Psychology attitude (V1) as an example to interpret the results, 3 items were submitted for measuring reliability analysis of Psychology attitude for Mechanical engineering students, Industrial Design and Technology students, Civil engineering students and Electrical engineering students respectively. All these items were scored on the same 5 point Likert scale (i.e. 1 = Strongly agree, 2 =Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly disagree). Given Cronbach's alpha (i.e. overall reliability of the scale) values of 0.816, 0.639 , 0.914 and 0.969 for mechanical engineering students, Industrial design and Technology students, Civil engineering students and Electrical engineering students respectively, the inference is that 81.6%, 63.9%,91.4% and 96.9 % of the variability in a composite score for Mechanical engineering students, Industrial Design and Technology students, Civil engineering students respectively and electrical engineering students (based on 3 items used for reliability analysis for Mechanical engineering students, Civil engineering students, electrical engineering students and Industrial Design and Technology students). Cognitive attitude would be considered as a consistent reliable variance (i.e., true score variance). This means that the scale used is reliable in that 81.6% (in the case of Mechanical engineering students), 91.4% (in the case of Civil engineering students), 96.9% (in the case of Electrical engineering students) and 63.9% (in the case of Industrial Design and Technology students) of the time, it will produce the same results when administered to the same participant (Mechanical engineering student, Civil engineering students, and Industrial Design and Technology student) in the same setting. Similar interpretations can be made for the remaining research variables (V2 to V3).

4.3.2 Factor Analysis

Beyond correlation analysis, the underlying structure for 9 items pertaining to attitude of engineering students in project prerequisites and the final year project was further assessed using factor analysis (principal component analysis) with varimax rotation (Fabrigar et al., 1999; Gorsuch, 2021). The independent sampling assumption was met. The assumptions of normality, linear relationships between pairs of variables, and moderate correlation between variables were then tested. The items were designed to index three constructs: cognitive, affective, and behavioral attitude. Three factors were therefore tested. Following rotation, the first factor accounted for 33% of the variance. The second factor accounted for 18.1% while the third factor accounted for 13.7%. Factor loadings less than 0.40 were omitted to improve clarity.

The results revealed a KMO of 0.737, indicating adequate items for each factor. This interpretation is based on the argument that KMO values greater than 0.70 indicate adequate items to predict each component while KMO values less than 0.50 indicate inadequate items. Bartlett's test was used to test for statistical significance (i.e., a significance value of less than 0.05). The results indicate that the variables are highly correlated enough to provide a reasonable basis for factor analysis.

4.3.3 Mann Whitney U-Test for Variations in the Attitudes of Engineering Students

A non-parametric Mann-Whitney U test was used to test for statistically significant variations in the attitudes of students among the four engineering departments (mechanical engineering, civil engineering, industrial design and technology and electrical engineering).

The results show an overall mean of 45, 9, 21, and 9 for Mechanical engineering students, Electrical engineering students, Civil engineering students and Industrial Design and Technology students respectively. P values of 0.05, 0.031, and 0.01 were obtained for students from the same three programs respectively. These p values are all below 0.05, indicating that the attitudes of students in Mechanical engineering, Electrical engineering, Civil engineering, Industrial Design and Technology is statistically different and significant. These results also indicate that Mechanical engineering students were the group mostly affected by behavioral attitude, followed by civil engineering students, then Electrical engineering and lastly Industrial Design and Technology students.

In addition, the results from Mann Whitney U-test showed significant differences between male and female students' attitude to final year project and its prerequisite in favor of male students. Male students had low mean scores for Psychological and Affective attitudes, which imply that they were less affected by Psychological and Affective attitudes as compared to female students. Female students obtained low mean scores for behavioral attitude, which suggests that behavioral attitude affected them to a lesser extent when compared to male students who missed classes and also participated less frequently in those classes. The outcome of the disparity in attitude towards prerequisites and the final year project is not surprising. Many students, especially female students, start lectures with some level of trepidation due to unpleasant experiences they may have had with prior coursework (Agoestina et al., 2022; Bayaga and Wadesango, 2014). This emotion frequently hinders students' ability to learn successfully and may cause partial withdrawal.

4.4 Relationships between Performance of Students in Project Prerequisites and Final Year Project (Objective 3)

This section contains result of regression analysis, descriptive statistics and Pearson's correlation used to compare performance of students in project prerequisite and the final year project.

4.4.1 Correlation and Regression Analysis between Project Prerequisites and Final Year Project

Table 7 presents results of regression analysis which was used to test for correlation between final year project and its prerequisite.

Table 7. Regression Analysis Results

Program of study	Relation between prerequisite and preceding course	Academic Year	Correlation(R)	Covariance(R2)	Statistical significance (F test)
Industrial engineering	IMB 324 (Productivity and Technology Management)to FYP 1	2017	0.67	0.46	0.04
		2018	0.27	0.68	0.01
		2019	0.11	0.11	0.03
	IMB 413 (Simulation Modelling) to FYP 1	2017	0.74	0.55	0.05
		2018	0.07	0.05	0.03
		2019	0.32	0.10	0.03
	IMB 423 (Process Planning and cost Estimation) to FYP 1	2017	0.32	0.10	0.01
		2018	0.06	0.04	0.06
		2019	0.48	0.24	0.05
	IMB 424 (Quality control)to FYP 1	2017	0.56	0.35	0.02
		2018	0.44	0.20	0.02
		2019	0.70	0.60	0.01
	IMB 515 (Operations Research II) to FYP 1	2017	0.01	0.00	0.08
		2018	0.11	0.12	0.05
		2019	0.13	0.02	0.07
	FYP 1 to FYP 2	2017	0.44	0.78	0.04
		2018	0.12	0.15	0.56
		2019	0.67	0.35	0.04
Mechanical engineering	MMB 432 (Fluid mechanics) to FYP 1	2017	0.6	0.36	0.01
		2018	0.35	0.13	0.06
		2019	0.42	0.17	0.07
	MMB 413 (Systems and	2017	0.09	0.08	0.04

	control Engineering) to FYP 1				
		2018	0.05	0.00	0.05
		2019	0.28	0.07	0.03
	MMB 434 (Heat transfer) to FYP 1	2017	0.14	0.02	0.01
		2018	0.17	0.03	0.04
		2019	0.10	0.23	0.05
	MMB 431 (Machine design) to FYP 1	2017	0.58	0.34	0.02
		2018	0.64	0.38	0.01
		2019	0.23	0.05	0.04
	FYP 1 to FYP 2	2017	0.78	0.80	0.08
		2018	0.64	0.75	0.03
		2019	0.38	0.15	0.04
Electrical engineering	EEB 343(Electrical Engineering Design) to FYP 1	2017	0.61	0.38	0.05
		2018	0.52	0.13	0.01
		2019	0.13	0.14	0.04
	EEB 463 (Electrical Engineering Laboratory) to FYP 1	2017	0.49	0.23	0.01
		2018	0.56	0.54	0.03
		2019	0.08	0.05	0.06
	EEB 444 (Electronic Experimental Design Laboratory) to FYP 1	2017	0.46	0.22	0.02
		2018	0.80	0.12	0.01
		2019	0.54	0.01	0.03
	EEB 464 (Power Transmission and Distribution) to FYP 1	2017	0.09	0.03	0.05
		2018	0.66	0.31	0.06
		2019	0.01	0.02	0.11
	EEB 465 (Power System Analysis)	2017	0.21	0.14	0.06

	to FYP 1				
		2018	0.43	0.14	0.02
		2019	0.10	0.22	0.05
	FYP 1 to FYP 2	2017	0.64	0.58	0.02
		2018	0.19	0.03	0.04
		2019	0.08	0.18	0.04
Industrial Design and Technology	IBC 511 to FYP 1	2017	0.23	0.05	0.01
		2018	0.11	0.21	0.01
		2019	0.32	0.40	0.05
	FYP 1 to FYP 2	2017	0.84	0.70	0.04
		2018	0.78	0.16	0.03
		2019	0.55	0.09	0.07
Civil engineering	CCB 441 (Principles of Civil Engineering)to FYP 2	2017	0.20	0.04	0.05
		2018	0.84	0.56	0.02
		2019	0.09	0.06	0.05
	CCB 442 (Geotechnical Engineering 11) to FYP 2	2017	0.21	0.04	0.01
		2018	0.07	0.05	0.03
		2019	0.14	0.10	0.01
	CCB 443 (Water Supply Engineering) to FYP 2	2017	0.84	0.70	0.04
		2018	0.31	0.13	0.05
		2019	0.44	0.56	0.02
	CCB 444 (Traffic Engineering) to FYP 2	2017	0.19	0.04	0.04
		2018	0.11	0.50	0.06
		2019	0.20	0.41	0.08
	CCB 445 (Wastewater Engineering and Management) to FYP 2	2017	0.14	0.04	0.05
		2018	0.32	0.39	0.01
		2019	0.11	0.02	0.03
Electronic	EEB 444 (Electronic	2017	0.51	0.26	0.06

engineering	Experimental Design Laboratory) to FYP 1				
		2018	0.48	0.08	0.01
		2019	0.03	0.12	0.03
	EEB 343 (Electrical Engineering Design) to FYP 1	2017	0.55	0.31	0.05
		2018	0.06	0.08	0.11
		2019	0.18	0.22	0.05
	FYP 1 to FYP 2	2017	0.45	0.30	0.01
		2018	0.67	0.77	0.08
		2019	0.34	0.67	0.02
Industrial engineering	IMB 324 (Productivity and Technology Management) to FYP 1	2017	0.67	0.46	0.04
		2018	0.27	0.68	0.01
		2019	0.11	0.11	0.03
	IMB 413 (Simulation Modelling) to FYP 1	2017	0.74	0.55	0.05
		2018	0.07	0.05	0.03
		2019	0.32	0.10	0.03
	IMB 423 (Process Planning and cost Estimation) to FYP 1	2017	0.32	0.10	0.01
		2018	0.06	0.04	0.06
		2019	0.48	0.24	0.05

Key: FYP 1= Final year project 1, FYP 2= Final year project 2

If there is a relationship between academic performance in project prerequisites and final year project, null hypothesis will be greater than 0 while a value of 0 indicates that there is no relationship. If the F value is less than 0.05, then the results are statistically significant while F values greater than 0.05 means than the results are not statistically significant. Covariance is used to describe how a change in the x variable influenced a change in the y variable. In this case it describes how a change in academic performance of project prerequisites (x variable) influenced a corresponding change in academic performance of the final year project (y variable). Using Industrial engineering program as an example, specifically the relationship between final year project 1 and the prerequisite IMB 324 (Productivity and Technology Management), In the academic years 2017/2018, 2018/2019, and 2019/2020, correlation test results show a relationship between final year project 1 and IMB 324 (Productivity and Technological Management) of 67%, 27%, and 11%, respectively. According to the covariance value, engineering students' academic performance on the prerequisite (Productivity and Technology Management) in academic years 2017/2018, 2018/2019, and 2019/2020, had an impact on 46%, 68%, and 11% of students working on their final year project. F values of 0.04, 0.01 and 0.03 were found, all of which are less than 0.05. This result imply a statistically significant relationship between engineering students' academic performance on the prerequisite (IMB 324 Productivity and Technology Management) and their academic performance on final year project 1.These results prove that there is a relationship between academic performance on prerequisites and academic performance on the final year project. This can further be proved by the correlation results tested for the following programs: Industrial Engineering, Mechanical Engineering, Civil Engineering, Industrial Design and Technology, Electrical Engineering, and Electronic Engineering (see Table 7).

4.4.2 Descriptive Statistics on Performance of Students in both Project Prerequisites and Final Year Project

In the context of descriptive statistics (means scores) concerning academic performance of engineering students in both the final year project and its prerequisites for 3 academic years (2017/2018, 2018/2019 and 2019/2020), it is clear that students performed way better in the FYP as compared to final year project prerequisites. If a sample is taken using mechanical engineering as an example, the academic performance of all final year engineering students on project prerequisites (Fluid mechanics, Systems and control Engineering, Heat transfer, Machine design) is below 70%. This result indicates poor to average performance, since 70% is the target mark for good performance. Final year project 1 and 2 had an average performance above 70%, indicating good performance. The variability between academic performance of engineering students in the final year project and its prerequisites may be caused by students' negative attitude towards final year project prerequisites. For example, 90% of engineering students indicated that project prerequisites were not important to them. It was not surprising to later discover that 69% of students missed their project prerequisites classes more than 2 times per week. The belief held by students that project prerequisites are not important was contradicted by regression analysis test results, which proved that there is a relationship between final project and its prerequisite. Covariance R squared further clarified this by indicating how academic performance of students in project prerequisites has been influencing academic performance in the final year project for the past three years in the Faculty of Engineering.

4.4.3 Pearson's Correlation Results

Results from Mann Whitney U-test revealed a statistically significant difference between the attitudes of male and female engineering students. On this basis, the two groups (male and female engineering students) were treated as separately entities in relation to subsequent statistical tests involving Pearson correlation. Behavioral attitude was measured by items 1, 2, and 3, while affective attitude was measured by items 4 and 5. Psychological attitude was measured by items 5 and 7. Conversely, items 8, 9, 10, 11, 12, 13 (academic performance items) indicate the academic performance of students from industrial engineering, mechanical engineering, civil engineering, industrial design and technology, electrical engineering, and electronic engineering in their final year projects, respectively.

According to the range of Pearson correlation reported in (Waldmann, 2019; Dienes, 2021) from -1 to 1, a value of 0 denotes a lack of correlation, while values between 0.1 and 0.3 denote a weak correlation. Values from 0.3 to 0.5 denote modest association between variables. Values above 0.5 to 1 indicate a strong correlation between variables. Pearson correlation results for male and female engineering students show that most correlation values fall between 0.1 and 0.5. These results signify that there is a moderate correlation between attitude and academic performance.

To verify the strength of the correlation between attitude and academic performance, a Bayesian correlation factor was conducted, which considered the following hypothesis:

H_0: There is a relationship between attitude and academic performance (null hypothesis).

H_1: There is no relationship between attitude and academic performance (alternative hypothesis).

A Bayesian correlation scale (Waldmann, 2019) is such that a value between 0.03 and 0.1 indicates strong evidence for H_0. Values between 0.1 and 0.3 indicate moderate evidence for H_0. Values between 0.3 and 1 indicate no evidence. Values between 1 and 3 show anecdotal evidence for H_1, while values between 3 and 10 show moderate evidence for H_1, and values between 10 and 30 show strong evidence for H_1. From these results, most Bayesian factor values were between 0.331 and 0.001. Therefore, the null hypothesis is accepted. This result implies that there is a moderately strong association between attitude and academic performance.

4.4.4 Summary of Relationships between Attitude and Performance on both Project Prerequisites and Final Year Project

Results from Mann Whitney U-test (Table 9) showed that most engineering students had a negative attitude towards learning. Results from Pearson's correlation Tables 12 and 13 indicated that there is a relationship between attitude and performance. This clearly explains why most students performed poorly in final year project prerequisite, as indicated by Table 10 of descriptive statistics. The results from Table 14, which contain the average enrollment numbers of students into prerequisites and the final year project, reveal a consistent conclusion regarding engineering students' negative attitude towards learning, which leads to poor academic performance. If a sample is taken using mechanical engineering, it can be seen that over a period of 2 years, on average, 30 students enrolled for final year project prerequisites and only 19 ended up passing all the prerequisites and enrolling for final year project 1. This indicates a failure rate of 36.7% in final year project prerequisites for mechanical engineering. The same phenomenon is seen in industrial engineering, which had on average only 14 students enrolling for final year project out of 30 students who were previously enrolled in project prerequisites demonstrating a failure rate of 53.3%.

Mann Whitney U-test results show that students enrolled in Industrial Engineering and Mechanical Engineering programs were identified to be the ones with the most negative attitude. Comparing academic performance of students enrolled in these two programs (Industrial Engineering and Mechanical Engineering) with academic performance of students enrolled in Industrial Design and Technology program, who were identified as students with the least negative attitude, these results clarified how attitude plays a vital role in academic performance. Over a period of 2 year Industrial Design and Technology had 41 students enrolled for the final year project prerequisites and 39 of them managed to pass all project prerequisites and enroll for the final year project. This result signifies a pass rate of 95%. Comparing this academic performance to that of students enrolled in Mechanical Engineering and Industrial Engineering programs, it can be deduced that students with negative attitude performed poorly as compared to students with positive attitude. These results show how attitude has a significant impact on academic performance of students and its potential effect on lowering engineering graduation numbers.

5. Conclusions

In the context of determining which stage of the final year project engineering students struggle the most and why, it was found that most students struggle with project progress (stage 2), for the following reasons: deficiencies in conducting and writing literature review, poor project management skills that impact on both data collection and procurement of material, and deficiencies in design aspects of mechanical engineering projects. These findings indicate the effectiveness of DMAIC methodology, as a lean six sigma tool to identify problems affecting academic performance of engineering students.

In the context of measuring the attitude of engineering students towards prerequisite courses to the final year project and the final year project, statistically significant results (conducted at a 95% confidence level) were obtained, demonstrating that there is a strong relationship between students' attitudes concerning both project prerequisite and the final year project, for all three engineering programs. These findings indicate that performance of students in prerequisites is associated with their academic performance in the final year project. The findings also suggest that students perform better in final year project as compared to prerequisites for all engineering programs.

Pearson correlation results indicated that there is relationship between attitude and academic performance. Negative attitude results in poor academic performance while positive attitude results in good academic performance. Mann Whitney U-test results revealed a significant variation in the attitudes of students across the three engineering programs. For example, mechanical engineering students have the most negative attitude, followed by civil engineering students and then industrial design and technology students. This finding increases our understanding of existing knowledge, where little is known about attitudes and academic performance of engineering students in both prerequisites and the final year project. In order to enhance academic achievement, a learning atmosphere where pupils are less inclined to adopt a negative attitude should be created. This includes adopting techniques such as alternative lecturing methods depending on the extent of difficulty in comprehending course material.

This study provides new knowledge concerning empirical evidence of attitudes of engineering students and its relationship with two performance indicators (academic performance on prerequisites and academic performance on the final year) for the first time, and hence prompts scholars and policy makers towards the need for a closer look at remedies for improving both attitudes and academic performance, with a view to produce competent engineers required by industry. Future work involves developing robust frameworks to guide effective engineering teaching and learning practices that may stimulate students' interests. Future studies may focus on other issues that influence engineering students' performance on the final year project.

6. Implications for Practice and Policy

The fact that engineering students are often unaware of their theory-related attitudes and beliefs, including their potential interrelations with learning motivation and emotions, has implications on both policy decision and hence practice. It is considered important to foster self-reflection on these aspects. A stronger reflection on these constructs could support professional development and promote learning, teaching, and evidence-based practice. This reflection can also be used as a stepping-stone for understanding and supporting how individuals react to and deal with engineering theories during their professionalization. In particular, this line of research can give rise to strategies and interventions for promoting and maintaining adaptive as well as reducing maladaptive theory-related attitudes and beliefs.

According to the study findings, students who possess positive attitude, are highly driven and confident in their own abilities are more likely to initiate high-quality learning. As a result, students must be eager to acquire new skills. This suggests, from the viewpoint of teaching, that the educational setting may and ought to support effective learning strategies, such as goal-setting, strategy choice, control, and evaluation of the learning process.

Another outstanding finding is that while females generally do not perform much below males in engineering courses, they are consistently affected by Psychological and Affective attitude which relates to higher levels of stress and lower levels of interest and hence negatively impacting enjoyment in engineering courses. This finding has significant policy implications because it indicates gender differences in the efficiency with which societies and institutions foster motivation and interest to a large extent, which calls for the need to assist female students in overcoming their apprehension about various topic areas. This approach may bring up issues on how to close the gender gap and a high degree of overall performance reached through the organization of schooling and instructional delivery, vital for the for engineering discipline.

Overall, the findings imply that education systems should make investments in strategies that focus on attitudes and learning behaviors and should regard this as a mission-critical objective on par with cognitive instruction.

In the current industrial engineering program, industrial analysis is an elective for students enrolled in mechanical engineering program. University management and policy makers should consider introducing this elective as a core course. This would help students to effectively analyze collected data to strengthen findings for students' final year project. In the current industrial engineering program, project management is an optional course. Faculty management and policy makers should consider introducing project management as a core course, such that students may benefit from this course in relation to the opportunity to learn how to effectively manage the stages of a final year engineering project in terms of deliverables. Given that the results revealed poor academic performance on design (a pre-requisite course) and specifically product design skills related to manufacturing, university management may need to introduce electives and optional courses, with a view to improve students' design skills.

Civil engineering program, along with industrial design and technology, may benefit from introducing continuous assessments relating to projects for core courses, given that the results revealed that engineering students enrolled in these programs struggle with aspects of projects (such as literature review) required for the final year project. Engineering students should be encouraged to make the necessary effort to conduct research and take full advantage of library resources, with a view to improve their research skills. Moreover, Laboratory technicians in industrial design and technology may benefit students' learning experiences by considering selecting reliable suppliers and using Just in time procurement processes to prevent shortage of material in laboratories. Engineering students with negative attitude should also be encouraged to take full advantage of University resources and services relating to professional guidance on counselling, offered free to all enrolled students.

In the context of control measures to ensure improvements in engineering students' academic performance, several control measures need to be put in place. These include regular inspections on engineering final year students by designated academic staff, to identify challenges facing students at an early stage. Control charts may be used to facilitate effective track record of students' academic performance in each academic semester. This approach may help in responding timeously to drastic changes in students' academic performance on both the final year project and its prerequisites.

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