Factors Affecting Problem-Solving Competency of Statistics Students in E-Learning: Education Perspectives Amidst the COVID-19 Crisis in the Philippines

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Abstract

Problem-Solving Competency of students in Statistics is a significant tool in the Engineering field for data analysis, risk assessment, and other domains. COVID-19 pandemic caused the school closures and learning loss that are evident to have a long-term negative impact on the current generation of school students. This affects the 3.2 million enrolled tertiary students in the academic year 2019-2021 with the new normal setting. This study aims to determine the factors that contribute to the Problem-Solving Competency of forty-six (46) Industrial Engineering students in the Technological Institute of the Philippines - Quezon City in the Statistics 2 course under the e-learning setting due to the cancellation of face-to-face classes. Specifically, the study sought to recommend solutions for the betterment of problem-solving skills of future Industrial Engineering graduates in the institution. Using online questionnaires and statistical analysis, factors such as instructor's teaching performance, student's attitude & engagement, and educational atmosphere in compliance with the new normal setting were found to affect the Problem-Solving Competency of Industrial Engineering students during the COVID-19 crisis. The identified factors need to be considered to improve the student's competency in problem-solving to have graduates who are proficient in solving complex engineering problems.

Keywords
Covid-19, Problem-Solving Competency, Statistics, E-learning, Industrial Engineering Students

1. Introduction

As a result of the global COVID-19 crisis, new issues have emerged because of significant adaptation and changes in the school system. Higher Education Institutions (HEIs), both public and private, had to conform to the new situation, which prohibited face-to-face interaction and mass gatherings (Novitasari et al. 2021). To comply with the Philippine government's quarantine regulations, colleges and universities adapted e-learning arrangements to curb the spread of the COVID-19 virus. This new setting contributes to several factors that affect the 3.2 million students enrolled in private and public higher educational institutions in the academic year 2019-2020 (Villanueva 2020).

Schools and other educational institutions require an environment that encourages and supports further growth in global competitiveness. According to a study published in 2021, it is important to evaluate students' problem-solving abilities because many universities strive to produce graduates who are proficient at problem-solving in at least one subject field. Statistics is a problem-solving process that seeks answers to questions through data. By asking and answering statistical questions, learning about the world would be possible (Anonymous 2020). It is an important tool in the engineering sector for robustness analysis, measurement system error analysis, test data analysis, probabilistic risk assessment, and many other domains (Zhan et. al. 2010). In accordance with the study year 2021, Problem-solving refers to the processes we employ to comprehend what is going on in our environment, identify items we decide to improve, and then determine what must be done to get the intended result which is at the core of human evolution. Problem-solving competencies enable people to assess, apply, or evaluate options in challenging situations from many perspectives by integrating a wide range of knowledge, methodologies, and skills. It is a high-dimensional cognitive function of humans, and it is important since it integrates the other core competencies that are used by the students throughout the years of college (Yoon et al. 2020). The competence level of students can be influenced by factors present in the course such as teachers as instructors, students as learners, and the student's environment as a supporter which might also contribute to its improvement (Xi et al. 2018).

Among the current research on problem-solving competencies, some studies have analyzed the factors of the problem-solving competencies among engineering employees in other countries (Yoon et al. 2020). However, even among these, it is difficult to find studies that focus on engineering students' problem-solving competencies, specifically this COVID-19 crisis, which is the category of research that would benefit Higher Education Institutions in the Philippines at present. Therefore, this study aims to identify the factors that affect the Problem-Solving Competency of Industrial Engineering students under the Statistics 2 course in Technological Institute of the Philippines - Quezon City.

1.1 Problem Statement

The present study wants to measure the factors that affect the Problem-Solving Competency of Industrial Engineering students in the Statistics 2 course under the new-normal setting due to the COVID-19 Pandemic.

Specifically, the study aims to answer the following:

1. What is the demographic profile of the Statistics 2 students?
2. Does the demographic profile (age and gender) of the Statistics 2 students affect the Problem-Solving Competency?
3. Do the factors (instructor's teaching performance, student's attitude and engagement, reading hours, and e-learning atmosphere) affect the Problem-Solving Competency of the Statistics 2 students?
4. Does the Problem-Solving Competency have a statistical relationship with the gender, age, instructor's teaching performance, attitude, engagement, reading hours, and e-learning atmosphere of Statistics 2 students?

1.2 Conceptual Framework

The IPO model was used as grounds for developing the research paradigm as presented in Figure 1 to provide a synopsis of the information that the researchers will gain from the assessment made on the questionnaires. This allows the study to determine which among the factors affect the Problem-Solving Competency of Industrial Engineering students in the Statistics 2 course in Technological Institute of the Philippines - Quezon City. The researchers provided questionnaires as the major instrument involved in this study.

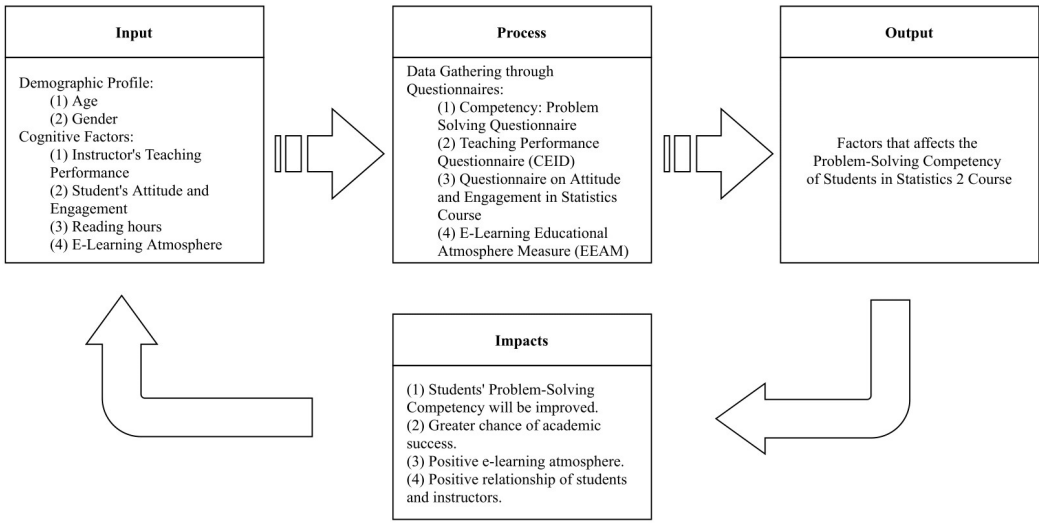

Figure 1. IPO Process of Conceptual Framework

1.3 Objectives of the Study

The study aims to identify the statistically significant factors affecting the Problem-Solving Competency of Technological Institute of the Philippines - Quezon City Students in Statistics 2 course under the e-learning setting as per the cancellation of face-to-face classes due to the COVID-19 crisis. The statistical information will be gathered using the online questionnaire to identify the respondent's Problem-Solving Competency given the factors such as the instructor's teaching performance, student participation, reading hours, and the student's atmosphere for e-learning. Specifically, the study sought to identify which factor contributes the most using statistical analysis to recommend solutions for the betterment of problem-solving skills of future Industrial Engineering graduates in the institution.

1.4 Significance of the Study

The present study plays a vital role to Industrial Engineering students as they will determine the factors affecting the Problem-Solving Competency of Industrial Engineering students in Statistics 2 under the e-learning system as per the cancellation of face-to-face classes due to the COVID-19. Furthermore, this study will give insights on how to analyze intervention and assessment between Problem-Solving Competency of Industrial Engineering students in the Statistics 2 and e-learning system which can contribute to the academic success of the students.

1.5 Limitations of the Study

The study assessed the Problem-Solving Competency of the students under the Statistics 2 course who enrolled during the COVID-19 in which the implementation of online classes became the major shift for institutions and colleges in the Philippines. The focus is the factors: instructor's teaching performance, students' attitude and engagement, reading hours, and educational atmosphere in an e-learning setting in assessing which among the factors affect the problem-solving competency of the respondents. The number of respondents is limited to forty-six (46) students with the use of purposive sampling given that the rest of the eighty-five (85) students under the Statistics 2 course during the S.Y. 2020-2021 are unresponsive. Therefore, the researchers utilized a significance level of 0.10 for Slovin's formula to arise with a smaller sample size in the study. Furthermore, the only tool used for data collection is an online form questionnaire in compliance with the COVID-19 protocols under the e-learning setting of the researchers. The data gathered were analyzed using correlational analysis and ordinal logistic regression due to the 4-point Likert Scale type of questions used in the survey. For the correlational analysis, the same significance level of 0.10 was utilized while 0.05 for the ordinal data to get better results of the relationship between the dependent and independent variables.

2. Literature Review

Covid-19 in relation to E-learning

The pandemic of the COVID-19 virus has widely affected the educational sector across the globe, forcing the institutions to shut down to control the spread of the virus. Due to this timely event, teaching professionals think of alternative ways of teaching during the lockdown that eventually resulted in e-learning or online learning, which made the students and instructors virtually connected (Radha et al. 2020). Banday et al. (2013) mentioned that since E-learning is still in its early stages of development, the implementation of this, faces multidimensional and varied challenges, particularly in developing countries. It is expected that academic institutions will integrate innovative content and teaching standards to adapt to these changes and for the development of new skills including problem-solving skills of students under distance digital learning (Schneider and Meirovich 2020).

Problem-solving

Problem-solving is a goal-oriented and purely cognitive activity that requires cognitive factors such as attention, use of memory, learning, and perception that must be coordinated effectively (Funke et al. 2017). It also entails systematic observation and critical thinking to find a better solution or path to the desired goal (Rahman 2019). In engineering education, problem-solving competency is one of the relevant skills, specifically to help the students to work with engineering models and solve engineering problems (Firouzian et al. 2014).

Instructor's Teaching Performance

According to Berkowicz and Myers (2017), instructors must become professionals at developing problems that require students to go back to previously learned knowledge and abilities while determining what they need to learn next to solve the problem. Students are engaged in the identification of the problem for problems to have relevance which will act as a guide for acquiring new knowledge and abilities. Teachers must now raise their game to meet the challenge of e-learning. Instructors must master the e-learning platform, analyze its potential uses, consider the platform's possible transitions of face-to-face teaching methods, synthesize the new method and tools for knowledge transfer, make an engaging presentation of new educational content, demonstrate, and visualize activities and results, and develop and improve skills to enhance the learning experience. To increase their performance when teaching online, teachers must undergo training and demonstrate competency (Mariani 2021).

Student Attitude and Engagement

Statistics is considered as one of the most difficult courses, and the attitude of students towards that course is significant in statistics education as it is a factor that affects the statistical achievement, literacy, or reasoning ability of students. Therefore, attitude towards statistics has an important role in the teaching and learning process in a class (Salim and Ayub 2017). It also has a vital role in students' engagement in statistics wherein a positive attitude will increase the achievement and performance of students in statistics reducing the likelihood of failing the statistics course (Gopal et al. 2018). On the other hand, student engagement in e-learning encompasses not only the behavioral performance of reading course materials, asking questions, participating in interactive activities, and completing homework but also the cognitive performance of learners' mental effort and initiative in applying new knowledge to a variety of situations when selecting and evaluating relevant information and resources, as well as the emotional performance of learners' satisfaction with their accomplishments (Hu and Li 2017).

E-learning Atmosphere

As stated in the study of Farhan et al. (2017), real-time multimedia processing tools and approaches for the e-learning paradigm are used to measure teaching performance and student learning experience. Lectures are recorded and presented to students in an e-learning educational setting, with their attention and involvement monitored. Another study explored the importance of the e-learning environment and investigated the analysis of weaknesses, strengths, challenges, and opportunities of online education in the time of the pandemic (Mayhoob 2020).

3. Methods

This chapter deals with the method and procedures utilized by the proponents. This includes the research design, respondents, research instruments and statistical treatment, which are important in interpreting and gathering data.

3.1 Research Design

The researchers applied a quantitative approach to get the quantifiable data and decided to use the descriptive research design to describe data about the respondents' instructor's teaching performance, attitude toward statistics, engagement in the class, reading hours, and atmosphere in an e-learning setting using an online google form with a combination of questionnaires used to determine the statistical results of analysis.

A. Independent Variables

The factors such as instructor's teaching performance, students' attitude and engagement in the class, reading hours, and educational atmosphere in an e-learning setting are the independent variables in the study. These factors pertain to how the instructors handle the online class, engagement of the student in the class, attitude towards the course, reading hours in the course, and the atmosphere under the e-learning setting. The atmosphere is composed of the programme effectiveness, teaching quality, ethics and professionalism, learner support, safety and convenience, and awareness of the rule's variables.

B. Dependent Variable

The Problem-Solving Competency of the Statistics 2 students is the dependent variable in the study because it was perceived that factors in the course of the students have a significant effect on the Problem-Solving Competency under the e-learning setting. It is divided into several variables such as analytical, getting to the root cause, seeking data and input, resourcefulness, and creativity & innovation.

3.2 Respondents

The participants of the study are the forty-six (46) students from the Statistics 2 course in Technological Institute of the Philippines - Quezon City during the academic year 2020-2021 who were part of the students who shifted to online class learning due to the cancellation of face-to-face for all levels of education in the Philippines. Participants were selected based on the students who were affected by the COVID-19 crisis. From this, the proponents conducted a study in two (2) sections of the Statistics 2 course to measure the factors that affect students' Problem-Solving Competency.

3.3 Methods and Instrument

The researchers used an online questionnaire to determine the factors affecting the Problem-Solving Competency of the respondents. The instruments used are Competency: Problem-Solving Questionnaires, Teaching Performance Questionnaire (CEID), Questionnaire on Attitude and Engagement in Statistics Course, and E-Learning Educational Atmosphere Measure (EEAM). The questionnaires are 4-point Likert Scale type combined with a single multiple-choice question on measuring the engagement of students in the Statistics 2 course.

The questionnaire was distributed online to the students enrolled in the Statistics 2 course during the academic year 2020-2021 in Technological Institute of the Philippines - Quezon City to gather data. It consisted of seven (6) sections: (1) Privacy Consent, (2) Student's Personal Information, (3) Student's Problem-Solving Competency, (4) Statistics 2 Instructor's Performance Evaluation, (5) Student's Attitude and Engagement, and (6) E-Learning Educational Atmosphere Measure. The study's background information, the proponents' information, and the respondents' privacy agreement are all included in the first portion of the questionnaire. The second portion had the demographic information of the respondents, which included their name, age, gender, and a question if the respondents take up IE 005 Statistics 2 in the academic year 2020-2021. The following sections are the questions used to gather the data for the dependent variable and independent variables of the study. The third section is for the Problem-Solving Competency variable with five (5) variables such as analytical, getting to the root cause, seeking data and input,

resourcefulness, and creativity and innovation. It is used to assess the Problem-Solving Competency of the respondents with a total of thirty-one (31) questions. The fourth section is the component for the instructor to evaluate teaching performance in the course consisting of twenty-six (26) questions. The fifth section includes the student's attitude and engagement that has forty (39) questions in total. It also includes the one (1) multiple-choice question for the reading hours corresponding to the hours that the students spend in reading for the statistics course. The sixth and last section has a total of thirty-seven (37) questions to measure the atmosphere of the respondents in an e-learning setting. It is divided into variables such as programme effectiveness, teaching quality, ethics and professionalism, learner support, safety and convenience, and awareness of the rules. To sum it up, one hundred thirty-four questions (134) were asked to the respondents to assess the factors affecting the Problem-Solving Competency of the respondents.

3.4 Statistical Treatment

The data gathered by the researchers were subjected to different statistical treatments using the software Minitab 19 for analysis and interpretation of data objectively using the following statistical tools:

Ordinal Logistic Regression. This was used to predict an ordinal dependent variable given three independent variables and for the ordinal type of data gathered using the 4-point Likert scale online survey questionnaire.

Correlational Analysis: This was used to identify the correlation between the dependent variable (Problem-Solving Competency of the Statistics 2 students) and independent variables (gender, age, instructor's teaching performance, student's attitude and engagement in class, and educational atmosphere in an e-learning setting) in the study.

3.5 Sampling

Using Slovin's Formula, the researchers calculate an ideal sample size from the population of 85 students enrolled in the Statistics 2 course in the academic year 2020-2021 in the Technological Institute of the Philippines - Quezon City with the desired confidence level of 90%. From the population of eighty-five, only 46 respondents will be needed in the study. The computation below shows how the sample size was determined:

$$n = \frac{N}{(1+N(e)2)}$$

Where:
N = population
e = acceptable margin of error = 0.10

$$n = \frac{85}{(1+85(0.10)2)}$$

$$n = 46\ respondents$$

4. Data Collection

The study included four measurements: (1) The Problem- Solving Questionnaire was used to emphasize the students on their knowledge in problem-solving skills, (2) The Teaching Performance Questionnaire (CEID) was used to assess university instructors' performance and effectiveness in teaching the course, (3) The purpose of the Questionnaire on Student Attitude and Engagement in Statistics Course is to measure and understand the student attitudes toward the course, as well as to assess students' level of engagement in the course, (4) The E-Learning Educational Atmosphere Measure (EEAM) was developed to analyze students' perceptions of the e-learning educational atmosphere in order to improve their learning.

In treating the data gathered, this study used the Minitab 19 statistical tool to treat the data acquired. To analyze the relationship between multiple variables, a summary of the findings will be presented using inferential statistics and cross-tabulation. Ordinal Logistic Regression was used to predict an ordinal dependent variable from a set of independent variables. The relationship between dependent and independent variables to the sample being tested will then be determined using Correlation Analysis.

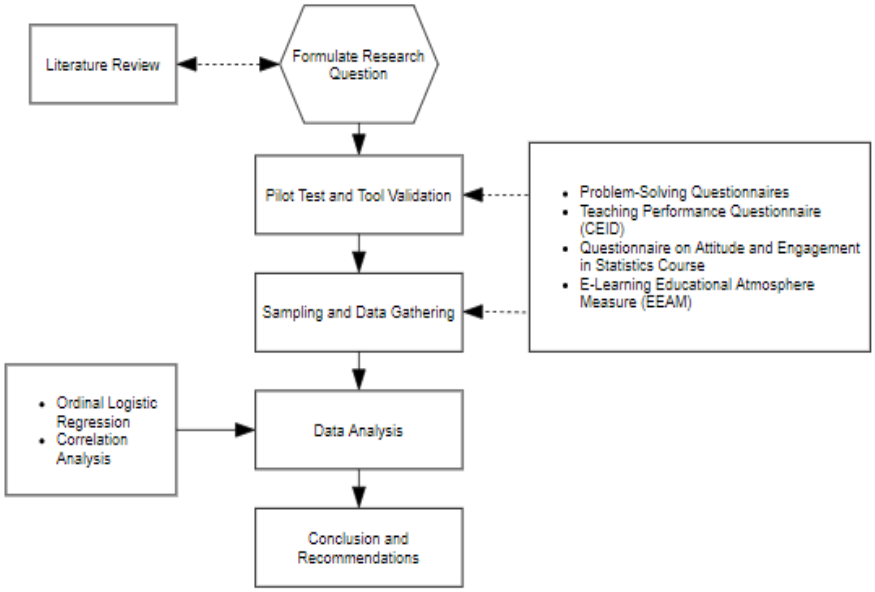

Figure 2. Data Collection Framework

5. Results and Discussion

The data gathered during the survey is presented, analyzed, and interpreted in this chapter. Each set of data was evaluated and interpreted in the context of the study's problem.

5.1 Numerical Results

5.1.1 Descriptive Statistics of Demographic Profile

Table 1. Descriptive Analysis of Statistics 2 Students' Demographics

Demographics	Frequency	Percentage	Mean	StDev
Gender				
Female	17	37%	21.412	11.040
Male	29	63%	24.724	14.687
Age				
19	1	2%	23	*
20	19	41%	23.947	12.808
21	20	43%	25.550	12.521
22	3	7%	15.667	21.127
23	1	2%	38	*
24	2	4%	3.500	0.707

Table 1 shows the descriptive analysis of the demographic profile of respondents provided a basis for the factors affecting the Problem-Solving Competency of Statistics 2 course students under the e-learning setting focused on gender and age. The population sample of forty-six (46) respondents includes the twenty-nine (29) males that are equivalent to 63% with a mean of twenty-four and 24.724 and a standard deviation of 14.687 while the remaining seventeen (17) or 37% respondents were female with a mean of 21.412 with a standard deviation of 11.040. Furthermore, it was identified that 43% of the respondents' age is 21 with a standard deviation of 12.521 while the lowest percentage of 2% is the age of 19 and 23.

5.1.2 Ordinal Logistic Regression (Between Dependent Variable and Demographic Factor)

Table 2. Ordinal Logistic Regression (Between Dependent Variable and Demographic Profile)

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% Cl	
						Lower	Upper
Gender							
Male	0.167	0.546	0.306	0.760	1.182	0.405	3.449
Age	0.110	0.264	0.414	0.679	1.116	0.665	1.873
Log-Likelihood = -151.679							

Table 2 shows the result of Ordinal Logistic Regression using Minitab 19 for the demographic profile of the respondents particularly gender and age using a 95% confidence interval. Both predictors are statistically non-significant with a p-value greater than the significance level of 0.05 indicating that the problem-solving competency of the student does not have different probabilities of occurring with the gender of the student and does not depend on the age of the student also. The positive coefficient for both predictors indicates that males are most likely to have the highest problem-solving competency rating with the odds of 1.182 and as age increases, the students mostly have the highest rating with the odds of 1.116.

5.1.3 Ordinal Logistic Regression (Between Dependent Variable and Cognitive Factors)

Table 3. Ordinal Logistic Regression (Between Dependent Variable and Cognitive Factors)

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% Cl	
						Lower	Upper
Instructor's Teaching Performance	-1.688	0.733	-2.303	0.021	0.185	0.044	0.777
Attitude	-0.697	0.748	-0.932	0.351	0.498	0.115	2.158
Reading Hours	0.052	0.073	0.713	0.476	1.054	0.913	1.217
Engagement	0.125	0.300	0.418	0.676	1.133	0.630	2.038
E-Learning Atmosphere	-1.535	0.761	-2.018	0.044	0.216	0.049	0.957
Log-Likelihood = -135.165							

Table 3 shows that using a 95 percent confidence level, it presents the results of ordinal logistic regression between problem-solving competency, instructor's teaching performance, student's attitude and engagement, reading hours, and e-learning atmosphere. The p-values for the performance of the instructors and the e-learning atmosphere are both less than 0.05. The negative coefficients of instructor's teaching performance and e-learning atmosphere, respectively, of -1.688 and -1.535, suggest that when the frequency measurements of instructor's teaching performance in class and e-learning atmosphere increase, the student's problem-solving competency decreases that affect students in Statistics 2 course.

5.1.4 Correlational Analysis Between the Dependent Variable and Independent Variables

Table 4. Correlational Analysis (Between the Dependent Variable to Independent Variables)

Factors	Problem-Solving Competency (Correlation Coefficient)	Strength
Gender	-0.063	No correlation
Age	-0.209	Weak Negative Correlation
Instructor's Teaching Performance	0.600	Strong Positive Correlation
Attitude	0.407	Strong Positive Correlation
Reading Hours	0.119	No correlation
Engagement	0.045	No correlation
E-Learning Atmosphere	0.591	Strong Positive Correlation

Table 4 shows the result of correlational analysis between the problem-solving competency and the demographic profile and factors specifically, the gender, age, instructor's teaching performance, attitude, reading hours, engagement, and e-learning atmosphere. The strength of correlation ranges from no correlation to a strong correlation, wherein the tables show a strong positive correlation as the highest strength among all the variables.

5.2 Proposed Improvements

The findings of this study can be used as reference data by future researchers when conducting a new or related study. This will serve as their starting point for gathering related information and making decisions. Furthermore, since the current study only had 46 respondents, the proponents suggest that future researchers should select respondents from larger sample sizes to calculate average data values more accurately and reduce errors caused by testing small sample sizes. Furthermore, the proponents suggest considering the factors present in the e-learning setting of the students under the Statistics 2 course such as the academic workload in the course, stress, General Weighted Average (GWA), and physical environment that could affect the performance of the students. Moreover, the study also highlighted the importance of Statistics 2 course to students and highly recommends further research to find other aspects of this subject to timely address the students' academic needs and performance.

6. Conclusion

This chapter contains a summary of the study, its implications, limitations of the study, and a recommendation based on the finding:

6.1 Summary of Findings

Based on the result of the study, the researchers found the following findings:

1. **The demographic profile of the Statistics 2 students.**

   Students at the Technological Institute of the Philippines - Quezon City in Statistics 2 class, which is mostly composed of 63% male and 43% are 21-year-old students, have no standard deviation since the data points tend to be quite close to the mean.
2. **The demographic profile (age and gender) of the Statistics 2 students in relation to the Problem-Solving Competency.**

   The results conclude that age has a lower likelihood of affecting the Problem-Solving Competency of Statistics 2 students and that gender does not affect it. Even though the findings show no significant relationship, females and males have different performances in problem-solving in some studies where males are shown to have higher problem-solving competency than females. Studies say that females have lower problem-solving competence than males and that at the age of 20's, the competence in problem-solving is statistically higher (Yoon et al. 2020) and revealed that it increases from that age to early middle age (Xi et

al. 2018). Therefore, the gender difference in that competence is seen in different performances but not statistically.

3. **The effect of factors (instructor's teaching performance, student's attitude and engagement, reading hours, and e-learning atmosphere) on the Problem-Solving Competency of the Statistics 2 students.**

   The instructors' teaching performance and the e-learning atmosphere are two factors that affect the problem-solving competency of students in Statistics 2. This agrees with the study which says that teacher intervention during the learning process influences degrees of progress in problem-solving competencies (Berkowicz 2017). Elaboration, managing the learning process, integrating information, generating engagement, and individual accountability are unique teaching responsibilities that affect learners' problem-solving competencies (Yoon et al. 2020). An e-learning environment is equivalent to the actual classroom environment which agrees with the study of where it is found out that problem-solving competency is highly correlated with the adequacy of e-learning (Keržič et al. 2018).

4. **Statistical relationship between the Problem-Solving Competency and the demographic profile, instructor's teaching performance, attitude, engagement, reading hours, and e-learning environment of Statistics 2 students.**

   Instructor's performance, attitude, and the respondents' e-learning atmosphere had a strong positive relationship with the respondents' problem-solving competency. The study of Yoon et al. (2020), "An Analysis of the Factors on the Problem-Solving Competencies of Engineering Employees in Korea", and Keržič et al. (2018), "Evaluating the impact of e-learning on students` perception of acquired competencies in a university blended learning environment" supports the findings of the researchers from the results interpreted from this study.

6.2 Implications

The findings can be applied to similar studies related to factors affecting Problem-Solving Competency of Industrial Engineering Students in the Statistic 2 course, such as instructor's teaching performance and the e-learning atmosphere during the new normal setting. The findings will aid similar studies to compare the student's problem-solving competency during e-learning and the face-to-face approach. The findings of this research will have a great value in the field of Industrial Engineering that will aid future research in the development of practice and help students to increase problem-solving competency during a new-normal setting. The study will also contribute to Industrial Engineering education using Industrial Engineering tools to perform analysis and identify the relationship between independent and dependent variables.

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