Jurnal Evolusi, Jilid 5, Bilangan 2 (November, 2024), pp. 23-30, e-ISSN: 2735-2234
https://journal.uptm.edu.my/index.php/evolusi

Exploring Student Emotional Experiences in Mathematics and Statistics Courses via Online Learning

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Received 30 September 2024, Revised 20 October 2024, Accepted 31 October 2024, Published 30 November 2024

ABSTRACT

The rapid adoption of online learning in higher education has transformed students' learning experiences, making the investigation of emotional responses in virtual learning environments increasingly important. This study examines the emotional experiences of Universiti Poly-Tech Malaysia (UPTM) students enrolled in Mathematics and Statistics courses during the April 2022 academic semester. Using a survey adapted from the Achievement Emotions Questionnaire-Short (AEQ-S), data were collected from students regarding their emotions before, during, and after online classes. The instrument comprised 24 items measured on a 10-point Likert scale ranging from strongly disagree to strongly agree. In addition, demographic and academic variables, including cumulative grade point average (CGPA), online learning tools, and internet stability, were gathered. Exploratory factor analysis was employed to identify the underlying dimensions of students' emotional experiences in online learning. The findings revealed a three-factor structure consisting of Frustration and Disengagement**,** Motivation and Achievement**,** and Anxiety and Apprehension**.** These factors highlight the multidimensional nature of students' emotions in online Mathematics and Statistics learning environments. The study contributes to a deeper understanding of how emotional experiences shape online learning engagement and provides insights for educators and institutions in designing emotionally supportive and effective virtual learning environments.

Keywords: *online learning, higher education, student emotion, factor analysis*

How to Cite:
Ishak, S., Ahmad Mokhtar, E. A., Abdul Rashid, N. F. W., Nik Rohaimi, N. N. S., Abdul Kadir, S., & Tajudin, H. (2024). Exploring student emotional experiences in mathematics and statistics courses via online learning. *Jurnal Evolusi*, *5*(2), 31–38. https://doi.org/10.61688/jev.v5i3.348

INTRODUCTION

Offering online learning environments is an increasingly prevalent practice in higher education institutions. They are regarded as a significant teaching strategy in higher education that can address problems with on-campus learning. Online lessons are available at any time and from any location, and this adaptability provides students with a wide range of placement options, from on-the-go placements amid their daily lives to dedicated time and space for learning (Landrum et al., 2021). It is generally recognized that learning settings affect not only the cognitive but also the emotional and motivational components of learning (AlAteeq et al., 2020; Gaballa et al., 2020). According to Sun & Zhang (2021), students revealed a dynamic shift from worry and curiosity to emotional stability during online learning. It also implies boosting students' social-emotional well-being, as well as encouraging students to self-regulate their emotions while learning online as well as at regular times.

In this study, the emotions towards online learning among 200 students at KUPTM were examined across different academic programs. Factor analysis is applied to analyze the factors influencing online learning among students. In factor analysis, the observed data values are represented as functions of many potential causes to determine which are most significant. The demographic characteristics considered were gender, academic program, course details, cumulative grade point average (CGPA), monthly household income, parents' occupation, online learning tools, data connectivity and internet access. While the students' emotions were pride, enjoyment, hopelessness, anxiety, boredom, and anger. All data was obtained via an online survey of students within one week.

LITERATURE REVIEW

Online Learning

In recent years, online learning has changed the way education is offered and received. Rapid technological innovations have converted traditional classrooms into digital platforms, allowing students to access instructional information from any location. Online learning is generally acknowledged as an effective strategy in higher education, but there is limited research on how students experience online learning environments emotionally. Higher education institutions are increasingly offering online learning environments to address the limitations of on-campus study. It is believed that online learning offers advantages, including reduced travel time and greater scheduling flexibility for students (Anshari et al., 2016).

Online education has been studied for decades, and effective online teaching results from careful instructional design and planning (Ilias et al., 2020; Wang et al., 2013). According to Anshari et al. (2016) and Ilias et al. (2020), learning technology innovations will continue to significantly influence teaching and learning methodologies in the coming years, increase student accessibility and promote higher completion rates. Technology mediates the connection between students and teachers, and the design of learning environments may significantly impact learning results (Bower, 2019; Gonzalez et al., 2020).

Although the impact of learning environments on the cognitive, emotional, and motivational aspects of learning is well understood, the acceptance and successful use of learning technologies are critical to realizing their advantages (Stephan et al., 2019). Limited evidence suggests that emotions affect learning in online settings. Further study on students' emotional experiences in online learning settings is required, particularly in education (Riegel & Evans, 2021; Stephan et al., 2019).

Emotion

Particularly in mathematics education, the adoption of online learning has become more widespread. Students' emotions are crucial to determining how well they learn as they transition from conventional physical classrooms to online settings. Math anxiety is a psychological condition that has received considerable attention in educational research because it substantially affects students' performance, attitudes, and overall well-being in mathematics education. Math anxiety can

also be described as a feeling of disquiet, anxiety, or fright when faced with mathematical activities or problems. It can show itself in a variety of ways, including physiological reactions (increased heart rate, sweating), cognitive distress (fright, racing thoughts), and emotional responses (fear, frustration), which prevent effective engagement with mathematical content (Ashcraft, Mark H., 1994; Biasutti, 2017)

Students' sentiments of disquiet and discomfort when engaging with mathematical knowledge are influenced by several elements, both intrinsic and external, which are complex phenomena that can be altered. Understanding these elements is essential for addressing and reducing pupils' fear of arithmetic. Negative experiences with mathematics in the past, such as failures or perceived inadequacy, can significantly impact a student's confidence and contribute to anxiety (Ashcraft & Krause, 2007). It outlines the main causes of difficulty with abstract mathematical concepts, including the teacher's teaching methods and attitude, as well as students' poor comprehension and analytical ability (Estonanto & Dio, 2019).

Anxiety regarding mathematics has significant effects on math education. To lessen anxiety and foster a pleasant math learning experience, educators should be aware of its presence and effects. In the future, studies should examine the efficacy of therapies across age groups and cultural contexts, as well as the neurological mechanisms underlying arithmetic fear (Lyons & Beilock, 2012). It discusses how interactive e-learning can reduce students' math anxiety and develop their mathematical resilience to support effective learning. Overall, the paper contributes to understanding math anxiety among business and management students and proposes e-learning as a potential strategy to address this issue and enhance students' mathematical skills and confidence (Jaggars & Xu, 2016).

Incorporating emotions into online education presents both opportunities and challenges. Individual subjectivity can hinder the effectiveness of emotionally resonant content, as the impact of emotions varies among students. Crafting emotionally engaging materials demands significant time and resources, potentially burdening educators and course designers. Striking a balance is vital, as excessive emotional emphasis might divert focus from the core subject matter (Artino, 2012). However, potential drawbacks also arise. Emotions might be misinterpreted, leading to unintended consequences (Pekrun et al., 2017). Inequities can emerge because not all students share the same emotional reactions; overemphasizing positive emotions might alienate those struggling with negative emotions related to math (Hannula, 2019). To harness the benefits of emotional integration, educational platforms must navigate these complexities skillfully to foster an inclusive and effective learning environment.

METHODOLOGY

Sample of Data

This study investigates the emotional experiences of UPTM students enrolled in Mathematics or Statistics courses during the brief April 2022 academic semester. Despite the transition to online education during the endemic phase, students' emotional responses were examined using a set of questionnaires administered via a Google Form link. A census study was conducted, and 200 students participated. The study utilized a modified version of the Achievement Emotions Questionnaire (AEQ-S), originally developed by Bieleke et al. (2021), to assess emotions such as pride, enjoyment, anger, anxiety, hopelessness and boredom. The AEQ-S consisted of 24 items that assessed emotional experiences before, during, and after online classes. Demographic information, encompassing variables like gender, academic program, course details, cumulative grade point average (CGPA), monthly household income, parents' occupation, online learning tools, data connectivity and internet stability, was also collected. A ten-point Likert scale ranging from "strongly disagree" to "strongly agree" measured the respondents' agreement with each item. Prior to survey administration, students received clarifications to ensure understanding of the items. To enhance the clarity, comprehension, and overall reliability and validity of the questions, a pilot test involving 86 students was conducted. This preliminary phase aimed to refine the phrasing of questions and gauge the instrument's reliability and validity. Using the Statistical Package for the Social Sciences (SPSS), Cronbach's alpha, a measure of internal consistency, was computed to assess the instrument's reliability. The outcomes of the internal consistency analysis for all questionnaire items are presented in Table 1, shedding light on the robustness of the scale.

Table 1: Reliability Statistics

CRONBACH'S ALPHA	N OF ITEMS
.783	24

In accordance with the data presented in Table 1, the alpha coefficient corresponding to all items is calculated at 0.783, signifying a substantial degree of internal consistency among the elements under examination. This outcome underscores notable coherence among the components. Consequently, the questionnaire attains a "very good" reliability classification, aligning with the established criterion of a reliability coefficient of 0.70 or higher as an acceptable threshold. (Bonett & Wright, 2017).

Data Analysis

The survey encompassed twenty-four items investigating emotional responses within the online learning domain. In this study, Factor Analysis (FA) with Principal Component Analysis (PCA) was employed to establish multiple emotional categories, thereby reducing the dimensionality of the variables. Several procedural steps are involved in conducting this analysis, including computing a correlation matrix, extracting factors, rotating them, and subsequently identifying the rotated factors.

FINDINGS AND DISCUSSION

The study's findings are primarily derived using Factor Analysis (FA) with Principal Component Analysis (PCA), with results obtained from the Kaiser-Meyer-Olkin (KMO) and Bartlett's Tests. The scree plot is then examined to identify the eigenvalues indicated by the curve. This process aids in locating the elements for extraction. The explanation for these findings is as follows.

Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

A KMO test is used to identify whether the factor influences the number of items and to measure the sampling adequacy for each item. It is found that the value of the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) equals 0.901, which is above the acceptable threshold value. It is suggested that the KMO value should be greater than 0.7 (Rasheed & Abadi, 2014). Bartlett's test of sphericity in Table 2 reports a Chi-Square = 3201.6885, df = 276, and a p-value < 0.000, indicating that the correlation matrix is not an identity matrix. Thus, factor analysis was suitable as the significance value of Bartlett's test was less than 0.05 (Shrestha, 2021). Subsequently, the Principal Component was used in extracting the items, and Varimax Rotation was applied to estimate the starting factor.

Table 2:
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.901
Bartlett's Test of Sphericity	Approx. Chi-Square	3201.688
	df	276
	P - Value	.000

Scree Plot

Cattell (2010) introduced a scree plot as a graphical tool to determine the number of factors to be extracted. The "elbow" is where the curve's slope visibly indicates the number of factors the analysis will generate. This test determines the number of factors that can be extracted from the items used. The scree plot in Figure 1 exhibits the number of components on the x–axis and eigenvalues on the y–axis. It can be seen that there are three factors, of which the eigenvalues are larger than one.

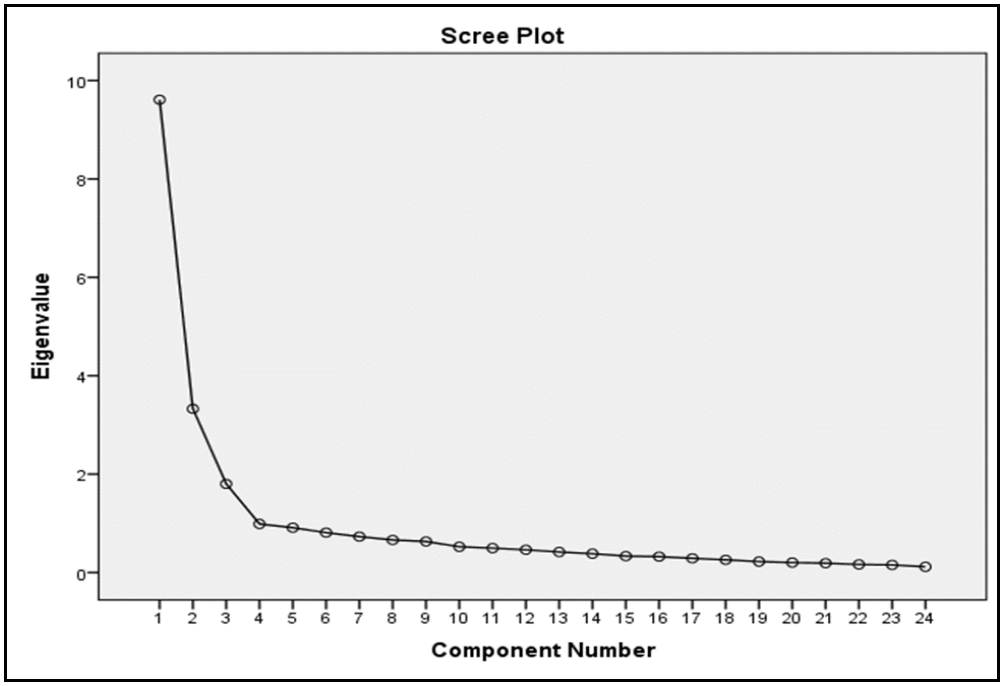

Figure 1: Scree Plot Diagram Showing the Eigenvalues of the Items

Factor Analysis (FA) with Principal Component Analysis (PCA)

Factor Extraction will depend on the factor loadings. Objects with factor loadings of 0 would indicate a lack of influence of the factor, whereas values closer to 1 or -1 will be more likely to influence the variable. In this research, items with factor loadings exceeding 0.5 are considered valid contributors. Table 3 shows the values of the rotated component matrix based on the factor loadings. It can be concluded that items 18, 5, 10, 16, 21, 13, 15, 7, 2, 1, 19 and 9 are classified as Component 1 named “Frustration and Disengagement". Next, items 24, 3, 6, 11, 8, 14, 22 and 23 are classified as Component 2, coded as "Motivation and Achievement". Lastly, Items 17, 4, 20 and 12 are grouped under Component 3 as "Anxiety and Apprehension".

Table 3: Categories of Factors

No.	Item
Emotion Group 1: Frustration And Disengagement	
18	Thinking about all the useless things I have to learn in mathematics/statistics makes me irritated.
5	I'd rather not go to the mathematics/statistics class because there is no chance of understanding the material anyway.
10	I feel anger welling up in me during the mathematics/statistics class.
16	I have lost all hope of understanding the mathematics/statistics material.
21	After the mathematics/statistics class, I am angry.
13	The mathematics/statistics class bores me.
15	Because I'm angry, I get restless in the mathematics/statistics class.
7	I feel like going out during the mathematics/statistics class because it is so boring.
2	Even before entering the mathematics/statistics class, I already knew that I wouldn't understand the material.
1	It's pointless to prepare for the mathematics/statistics class because I don't understand the material anyway.
19	I find the mathematics/statistics class fairly dull.
9	I get bored during the mathematics/statistics class.

Emotion Group 2: Motivation and Achievement	
24	Because I take pride in my accomplishments in mathematics/statistics, I am motivated to continue.
3	I am motivated to go to the mathematics/statistics class because it's exciting.
6	I enjoy being in the mathematics/statistics class.
11	I feel good when I am in the mathematics/statistics class, listening to the lecturer's talk.
8	I take pride in keeping up with the material in the mathematics/statistics class.
14	I am proud of the contributions I have made in the mathematics/statistics class.
22	I think that I can be proud of what I know about mathematics/statistics.
23	I'm glad it paid off to go to the mathematics/statistics class.
Emotion Group 3: Anxiety and Apprehension	
17	I get scared that I might say something wrong in the mathematics/statistics class, and I'd rather not say anything.
4	I worry about the difficulty of the things I might be asked to do in the mathematics/statistics class.
20	When I don't understand something in the mathematics/statistics class, my heart races.
12	I feel nervous in the mathematics/statistics class.

CONCLUSION

In conclusion, online learning is significantly influenced by emotions. Negative emotions can undermine the learning process, while positive emotions can increase engagement and retention. This study categorises emotions among UPTM students enrolled in Mathematics and Statistics courses during online learning. Twenty-four items have been grouped under three components based on the students' emotions. In summary, the analysis results show that a set of items, including 18, 5, 10, 16, 21, 13, 15, 7, 2, 1, 19, and 9, form Component 1, characterized as "Frustration and Disengagement". The following items are included in Component 2, "Motivation and Achievement": 24, 3, 6, 11, 8, 14, and 23. Items 17, 4, 20, and 12 are included in Component 3, "Anxiety and Apprehension," as their name suggests. It is recommended that future research focus on these three components in analysing data. Various data analyses can be conducted, such as multiple linear regression, logistic regression and others. Hence, using a smaller number of variables obtained from factor analysis can help avoid multicollinearity.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Universiti Poly-Tech Malaysia for providing the resources and support necessary to complete this study. We would also like to thank all participants who contributed their time and insights to this research. Special appreciation is extended to colleagues and peers who offered valuable feedback during the development of this manuscript.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper.

ETHICS STATEMENT

This study was conducted in accordance with the ethical standards of the relevant institution. All participants were informed about the purpose of the study and provided written informed consent prior to participation. Participants' privacy and confidentiality were maintained throughout the research, and all data collected were used solely for academic purposes.

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