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Exploring Mathematics Anxiety among Undergraduate Engineering Students

Krishna Chandra Paudel

Mahendra Ratna Campus, Tribhuvan University

https://orcid.org/0000-0003-3381-0248

kcpaudel@trinitycollege.edu.np

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Abstract

This paper explores the level of mathematics anxiety and the factors influencing the undergraduate study of engineering mathematics. Semi-structured interviews were conducted on purposively selected ten bachelor-level engineering students. The data thus obtained were analyzed using descriptive qualitative research design. Four main themes were identified viz. (1) students' low self-esteem, (2) unfriendly pedagogical practices, (3) unfavorable institutional decisions and practices, and (4) a hostile examination system and laden contents. This study recommends a support system that includes counselling, motivation, teacher support, etc. to overcome mathematics anxiety among bachelor level engineering students.

Introduction

Mathematics anxiety is a global phenomenon that can hinder students' performance (Lee, 2024). The level of anxiety in mathematics and performance in the subject are inversely related across all educational stages, including schoolchildren (Chiu & Henry, 1990; Ma, 1999; Saigh & Khouri, 1983) and college students (Betz, 1978; Frary & Ling, 1983; Lee, 2024). Mathematics anxiety poses a great trouble in engineering education, likely obstructing academic achievement and professional growth among undergraduate students (Lee, 2024).

Even though mathematics plays a crucial role in engineering programs, research shows that engineering students face different levels of mathematics anxiety (Prahmana et al., 2019). This psychological phenomenon, marked by sensations of nervousness and unease particularly associated with math-related assignments, can greatly affect students' capacity to handle numerical tasks and tackle intricate challenges (Gresham, 2010). Although considerable research has focused on mathematics anxiety among general student groups, less focus has been placed on its particular expressions and consequences within engineering education settings. Grasping the extent and influence of mathematics anxiety in engineering students is essential, given that these students frequently interact with complex mathematical ideas and applications during their educational journey (Prahmana, 2019).

Various concept areas in mathematics ranging from computation skills to problem solving, as well as difficulties with language and communication skills, assessment and evaluation of students, teacher roles, and even level of difficulty of the curriculum can predicate symptoms of math anxiety (Finlayson, 2014; Furner & Duffy, 2002). Furner and Berman (2003) identified impact factors such as poor attitudes and lack of positive influence from teachers, strategies and instructional techniques used in the classroom, and the structural system of a school as additional potential causes of math anxiety (Furner & Duffy, 2002; Paudel, K. C., 2023).

The levels of mathematics achievement in Nepal indicate a troubling situation, as NASA (2020) noted by Khanal et al. (2022) that achievement rates are merely 32.1%, which is considerably below average. Further, this subpar performance may arise from multiple factors, with mathematics anxiety surfacing as a significant issue that hinders learning results. Although Belbase (2013) has identified the link between mathematics anxiety and student performance in Nepal, emphasizing the possibilities of suitable teaching methods, a considerable gap still exists in comprehending this issue, especially regarding undergraduate

engineering students. This gap is particularly significant since engineering education significantly depends on mathematical skills for professional success.

The importance of this research arises from both empirical data and real-world observations in the educational setting of Nepal. Twenty years of professional experience in mathematics education shows a recurring trend where students perceive mathematics as a source of stress and disinterest, instead of as a valuable tool for problem-solving. This anxiety impacts not only immediate learning results but also has wider consequences for Nepal's educational goals and the growth of technically proficient professionals. This study concentrates on undergraduate engineering students, tackling an important but overlooked aspect of mathematics anxiety within Nepal's higher education system. Grasping the environmental elements that lead to mathematics anxiety in this context is crucial for creating focused interventions and enhancing overall educational results in technical fields. Contextual factors have the potential to contribute to mathematics anxiety (Cemen, 1987; Kelly & Tomhave, 1985). Global literature on math anxiety has reported the effects of the role of interpersonal factors like the role of teachers, parents, peers, and school environment as well as intrapersonal factors like metacognition, self-efficacy, and self-esteem (Barnes, 2006; Jameson, 2014; Legg & Locker, 2009; Rubinston & Tannock, 2010). This study aims to identify and explore the significant presence of mathematics anxiety in undergraduate engineering students, aiding in both theoretical insights and practical remedies for this widespread educational issue.

Theoretical Foundation of the study

Horney's theory of anxiety

Karen Horney's innovative theory of anxiety marks an important departure from conventional psychoanalytic views by highlighting the impact of sociocultural factors and early childhood experiences on the development of anxiety (Horney, 1945). She suggested

that anxiety arises mainly from broken human connections, especially due to inconsistent or insufficient parenting, which instills a profound sense of fundamental anxiety and powerlessness in children (Horney, 1950). She outlined issues that include a lack of affection, support, engagement, or stability. She contests Freud's biological determinism by claiming that anxiety patterns are influenced by cultural dynamics, interpersonal connections, and social contexts, indicating that a person's feelings of worthlessness and self-doubt arise not from inherent predispositions but from early encounters with emotional neglect, hostility, or erratic care from primary caregivers (Paris, 1996). Additionally, Horney identifies three adaptation styles: passive, aggressive, and withdrawn. Horney suggested that the four distinct methods for handling basic anxiety included seeking affection and love, adopting a submissive stance, gaining power, and retreating.

Bourdieu's Notion of Social Practice

Pierre Bourdieu's idea of social practice illustrates an insightful framework for comprehending anxiety as a socially created phenomenon intertwined in everyday life. His theory sheds light on how anxiety appears through learned behaviors and ingrained tendencies (habitus) that individuals develop through socialization processes and everyday interactions (Bourdieu, 1990). The emergence of anxiety-related behaviors is closely linked to an individual's social and cultural capital, as the reactions to stress and uncertainty are influenced by the shared practices of the surrounding social environment. This viewpoint corresponds with Vygotsky's focus on social development, indicating that anxiety forms are not just individual psychological conditions but are acquired through social interaction within particular cultural settings, where people internalize anxiety responses by engaging in social practices and steering through different social arenas.

Methodology

Methodology covers the selection of the study site and participants, the data gathering process, and the analysis of the data. The researcher adopted qualitative research, particularly have used an interpretative research paradigm to conduct this study because it assumes a relativist ontology, a subjective epistemology, and a naturalistic set of methodological procedures (Creswell & Poth, 2018). The study's ontological stance was that as students have a variety of histories, psychological perspectives, embodied knowledge, and behaviors, they all have unique experiences. To understand the reality of the mathematics anxiety of undergraduate engineering students, students of different semesters and stems were interviewed. The interviews were conducted to understand the interviewees' multiple narratives and interpretations (Creswell & Poth, 2018). Thus, by examining and evaluating people's experiences, viewpoints, and behaviors, the knowledge of mathematics anxiety was produced. The researcher made the assumption that there were many social realities based on participant viewpoints while analyzing the data. In this way, an interpretive research paradigm guided this study.

Study Site and Selection of Participants

Most of the engineering colleges of different universities and majority number of students have been pursuing their engineering study at Kathmandu Valley. Kathmandu valley was taken as the study site. Qualitative researchers usually work with a small sample of people nested in their context and conduct an in-depth study (Miles & Huberman, 1994). The qualitative information is based on participants' subjective views. The researcher purposively selected ten engineering students five from computer and five from civil department as the participants who had high level of mathematics anxiety. The participants were finalized through the classroom observations, teacher interactions and analysis of past academic

achievements of the students. Pseudo-names of the sample students *Shree, Shiva, Alex, Hari, Keshav, Swasthi, Salu, Krisha, Janu and Aagya.*

In-depth Interviews

An in-depth interview serves as a flexible tool for gathering qualitative data, allowing for the use of multiple sensory channels, such as verbal, spoken, and auditory (Cohen, Manion, & Morrison, 2008). The in-depth interviews were conducted by thoroughly investigating the topics related to the study and the complete spectrum of concepts and thoughts on mathematics anxiety in students (Sullivan, 2001). A set of interview guidelines was created featuring a sequence of questions designed to elicit a detailed narrative of the participants' views (Moustakas, 1994). The interview typically started with a casual chat to foster trust and develop a comfortable environment, allowing the researcher to connect with the participants. Every interview session was recorded in audio format for transcription, translation, and analysis.

Ethical considerations

This study followed ethical standards, maintaining the confidentiality, anonymity, and voluntary involvement of participants. All participants were provided informed consent, and they have given the choice to exit the study at any point without facing any repercussions. The research also received ethical assessment and authorization from the concerned authority.

Researcher's Stance and Focus

In this, study the researcher's position was insider. Dawyer and Buckle (2009) discuss the role of an insider in the research process, emphasizing the use of narratives, voice, transcripts, ethical issues, and the support of study participants. An insider researcher possesses a shared identity, language, and experiences with the participants of the study. Insider researchers possess values, viewpoints, behaviors, beliefs, and knowledge that are the

focus of the study (Greene, 2014). The basic focus of the study was students' perceptions and manifestations of math anxiety in relation to engineering studies.

Data Analysis

Ten students exhibiting very high level of anxiety in mathematics were chosen to take part in this research. All interviews were conducted with the consent of the participants, then transcribed exactly as spoken. The collected data were transcribed and translated from Nepali into English. The transcripts that were translated were examined multiple times to comprehend the notions and ideas that emerged in relation to the study issue. Utilizing the qualitative research method, comparable themes were explored from the transcripts while considering individual viewpoints. The unit of analysis for the qualitative data consists of direct quotes from the participants. A total of 140 quotes were used as primary data for the analysis. Following a thorough understanding of the information, key concepts and notions were coded depending on their meanings and significance for the study questions. The coding process involved segmenting and labeling concepts from the transcription text to form narratives and general themes in the data. An attention was the students' self-esteem, contents and pedagogical practices, institutional decisions and practices, examination system**.**

This study followed Mishler (1995) models of narrative analysis and focused on "reconstructing the told from the telling." The researcher has reassembled the participants' stories from the fragments of interview data, arranging in a cohesive thematic structure and interpretation. Multiple themes emerged from the information. A follow-up interview was carried out with each participant. The data from these interviews assisted in solidifying the themes. The upper-level themes, formed by blending the lower-level themes, were created on or after the quotes obtained from the interviews. Similar themed quotes were grouped and categorized. Level I themes were generated from the shared themes of direct quotes, level II themes stemmed from level I, and level III themes were based on level II themes.

Results and Discussion

The illustration presented below represents content analysis employing an inductive method. Figure 1 illustrates the themes that emerged through the interviews were linked to qualitative aspects related to math anxiety among bachelor's level engineering students. While talking to the students, they confessed that, pedagogical practices, insufficient feedback and support system creates unfriendly pedagogical practices which is a cause of mathematics anxiety. Few of the responses of the students regarding the roots of mathematics anxiety are mentioned below as testimonies:

> "I slump in my seat while Professor Thapa recites yet another formula. 'Write this down!' he shouts, speeding through derivatives. My classmates hurriedly copy, none audacious enough to inquire 'why?' or 'how?' We're not acquiring the ability to think—we're merely human storage devices, recording information without understanding". (*Alex, BE I semester student*)

> "As I look at the multiple integral, my chest constricts. 'This is basic calculus,' Dr. Gautam scoffs when I request an explanation. Beside me, Shiwani scared and felt helpless situation. As asking questions during class results in public embarrassment. Mathematics has turned into our everyday ordeal". (*Shree, BE II semester student*) "Those who are unable to solve this should not be in engineering," Professor Bhatta declares, observing our worried expressions. My friend Shiva's fingers drum anxiously on his desk—an impulse that started after failing the last three exams. Even though we stayed up late studying as a group, we're lost. The impatience of our teacher hinders the learning process. Every class resembles entering a trouble arena". *(Swasthi BE II semester student*)

Examples of Quotations	Level I Themes
"Teachers are in the mode of knowledge dispensers rather than facilitators" "Our teacher is less supportive" "I have unpleasant experience regarding	Teacher attitudes and behavior
"I get really upset. I can hardly focus in class and don't do well on examinations too" "Exam scores are prioritized over concepts" "My class is not cooperative. We rarely have a dialogue on mathematics problems, classes are	Pedagogical
"I could not get extra support in math learning" "I could never receive foundational details of mathematics learning, it's always a burden to me" "I always feel helpless at math classroom."	Insufficient Students support/

Figure 1: Quotations Cluster and First Level Themes

The first narration shows teachers are in the mode of knowledge dispensers rather than facilitators. The second and third narrations indicate that the teacher is less supportive and students had unpleasant experience regarding math teacher. The theme teacher attitudes and behavior mentioned below, representative remarks are used to explore students' perceptions of mathematics learning. Students' comments about mathematics learning demonstrate that mathematics anxiety is proportional to teacher negative attitudes and behavior.

Engineering students demonstrated considerable frustration and anxiety about their mathematics education, emphasizing various key issues. They view their teachers as simply "providers of information instead of supporters," resulting in "negative experiences related to mathematics instructors." Pupils express feelings of anxiety in mathematics lessons, stating, "I become very frustrated." "I struggle to concentrate during class and also perform poorly on tests," which indicates how anxiety impacts their performance. The teaching method seems to have issues, with concerns that "test results take precedence over understanding" and "classes

are a one-sided exchange" lacking collaborative discussion. The challenge of learning mathematics without a solid foundational understanding amplifies their anxiety. Students express a strong sense of neglect in their educational experience, stating that "I constantly feel lost in math class" and grieving that "I couldn't receive additional help with math studies." The weight of mathematics lacking solid foundations is notably concerning, as students express, "I could never obtain the basic details of math learning; it continually feels burdensome to me," establishing a cycle where students become more disconnected from a subject crucial to their engineering studies.

Based on the thematic analysis diagram, mathematics anxiety in bachelor engineering students seems to arise from three primary level III themes: unfriendly pedagogical practice, Low Self-esteem, and hostile testing systems with laden course contents. The diagram illustrates how these themes arise from more specific level I issues, including teachers' attitudes, inadequate support, negative attitudes towards mathematics, poor self-concept, and a complicated course structure. The study uncovers a complicated relationship between institutional factors and individual psychological aspects that lead to mathematics anxiety. Students' experiences unwelcoming teaching methods and inadequate feedback, along with their own poor self-perception and understanding issues, result in a difficult learning environment. These results are aligned with the results of previous researches (Barnes, 2006; Jameson, 2014; Legg & Locker, 2009; Paudel, K. C., 2023; Rubinston & Tannock, 2010). The existence of intricate content, ambiguous assessment systems, and unfavorable institutional decisions intensifies this anxiety, indicating that addressing mathematics anxiety necessitates interventions at both teaching and institutional levels, along with assistance for students' psychological well-being.

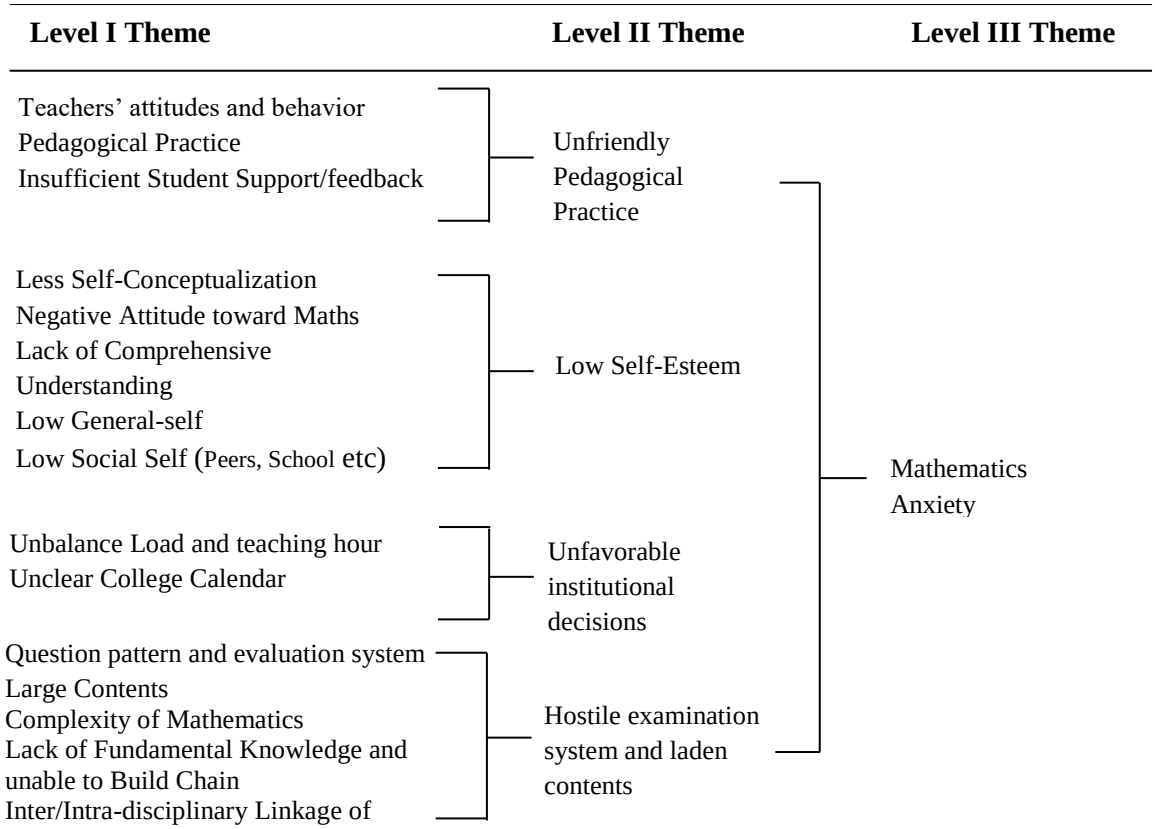

Figure 2. Nexus of three level themes

The mathematics anxiety encountered by BE students can be analyzed through Karen Horney's anxiety theory and Pierre Bourdieu's model of social practice. Horney's concept of anxiety stemming from dysfunctional human interactions and hostile environments (Horney, 1950) aligns with the empirical findings apparent in the thematic analysis. The Level I themes, particularly the teachers' attitudes and insufficient support for students, create what Horney calls "basic anxiety" in learning mathematics. This becomes evident in student testimonials like Shiva's comment regarding inadequate support from instructors and classmates, demonstrating Horney's concept of isolation in unwelcoming environments (Horney, 1945). The manifestation of anxiety through a poor self-image and pessimistic attitudes toward math is in direct correlation with Horney's theory about the impact of anxiety on personality development and academic achievements (Paris, 1996).

Bourdieu's theoretical model, particularly his concepts of 'habitus' and 'field' (Bourdieu, 1977), provides significant insights into the institutional and structural factors revealed in Level II and III themes. The field of mathematics education, characterized by discouraging teaching approaches and adversarial evaluation frameworks, shapes students' mathematical 'habitus' - their tendencies and views about mathematics (Bourdieu & Passeron, 1990). This is clear in Level I themes such as "Low General-self" and "Low Social Self," highlighting how students grasp their position in the field of mathematics. Swasthi's examination of the curriculum demonstrates what Bourdieu calls 'symbolic violence' in educational systems (Bourdieu & Wacquant, 1992), where institutional practices create and maintain anxiety. This theoretical synthesis suggests that effective interventions must address personal psychological support alongside institutional transformations, as mathematics anxiety emerges not just as an individual psychological concern but also from complex social and institutional practices affecting students' educational experiences.

Limitations, Conclusion and Implications

Limitations

Recognizing specific limitations of a study is essential. Initially, the study focuses on undergraduate engineering students from designated universities, potentially impacting the applicability of the results. Secondly, the self-reported nature of the data collection techniques might lead to response biases. This study seeks to deliver an in-depth understanding of mathematics anxiety in engineering students by using qualitative research design and qualitative data, offering valuable insights to educational institutions and support services for effectively tackling this issue.

Conclusion and Implications

Mathematics anxiety in a learner is a socially constructed phenomenon. Effective mathematics education involves reducing high levels of anxiety while harnessing low levels

of anxiety to motivate and engage learners. Mathematics anxiety in learners is influenced by different factors: students' low self-esteem, unfriendly pedagogical practices, unfavorable institutional decisions and practices, and hostile examination system and laden contents. The necessity of stakeholders nourishing assistance which comprises counseling, encouragement, teacher help, and other measures to overcome high level of mathematics anxiety among bachelor level engineering students. In addition, to reduce mathematics anxiety and create a comfortable learning atmosphere, these contextual factors need attention, with teachers playing a crucial role in addressing the issue.

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