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Building resilience in mathematics: Innovating teacher training on cognitive load, dissonance, and math anxiety

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ABSTRACT

This mixed method research design aimed to determine the levels of cognitive load, dissonance and math anxiety of students as a basis for developing In-Service Training Program. The participants included 395 Grade 9 students across the Division of Iloilo. The instruments used in this study were the adopted checklist questionnaires: cognitive load, cognitive dissonance and math anxiety. A separate questionnaire served as a focus group discussion (FGD) guide for students. Descriptive statistics, including mean, frequency, percentage, and standard deviation, were employed. Inferential analyses included ANOVA to test for significant differences and Pearson's r to examine significant relationships, with the alpha level set at 0.05. Major findings of the study revealed that students have high level for cognitive load as a whole and in terms of intrinsic and germane loads the students have high level and moderate level for extraneous load in mathematics learning. For cognitive dissonance in mathematics learning, result revealed a moderate level. For mathematics anxiety result revealed a high level. No significant difference in mathematics anxiety among the levels of cognitive load in mathematics learning and no significant difference in mathematics anxiety among the levels of cognitive dissonance in mathematics learning. Additionally, there was no significant relationship between cognitive load and cognitive dissonance in mathematics learning. Likewise, there was no significant relationship between cognitive load in mathematics learning and mathematics anxiety. However, there was a significant relationship between cognitive dissonance in mathematics learning and mathematics anxiety and a very weak, negative correlation between cognitive dissonance and mathematics anxiety, with high levels of cognitive dissonance associated with lower levels of mathematics anxiety. Moreover, cognitive load was not a significant predictor of mathematics anxiety, while cognitive dissonance was a substantial predictor of mathematics anxiety. Lastly, An In-Service Training Program was developed to help students manage cognitive load, navigate cognitive dissonance, and reduce mathematics anxiety.

Keywords: Cognitive load, cognitive dissonance, mathematics anxiety, in-service training program

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INTRODUCTION

Mathematics plays a vital role in enabling individuals to participate meaningfully in society, as it equips learners with essential knowledge, skills, and understanding necessary for problem solving and informed decision making in everyday contexts. Despite its importance, mathematics is commonly perceived by learners as difficult. Recent perspectives in mathematics education emphasize that instruction should move beyond the transmission of content and procedures toward a focus on students' lived experiences of the discipline and the development of mathematical sense making (Schoenfeld et al., 2019). Within this view, instructional design becomes a critical determinant of effective teaching and learning, as it strongly influences how students process, understand, and retain mathematical knowledge. Effective instruction therefore requires teachers to ground their practices in evidence-based principles of cognition, particularly those that support meaningful learning and reduce unnecessary mental strain (Houichi & Sarnou, 2020).

One of the most influential cognitive frameworks in mathematics education is cognitive load theory, which is grounded in two fundamental assumptions. First, the human working memory has a limited capacity for processing new information at any given time, and second, long term memory has no known limits in terms of the amount of information it can store and process (Schoenfeld et al., 2019). The primary goal of cognitive load research is to design instructional techniques that align with the constraints of working memory in order to maximize learning. However, several factors hinder effective cognitive load management in mathematics learning. In the Philippine context, many students are taught using traditional, teacher centered approaches that emphasize rote memorization and procedural recall rather than conceptual understanding. This instructional orientation often imposes unnecessary cognitive burden, as students attempt to apply formulas and procedures without a clear grasp of underlying concepts, resulting in confusion and reduced learning efficiency (Zhang et al., 2023).

Globally, cognitive load has emerged as a central issue in mathematics education, prompting educational institutions to adopt teaching strategies that aim to reduce excessive mental demands. These strategies include breaking complex problems into smaller steps, using visual representations, and incorporating real world applications to support abstraction and conceptual understanding (Dela Cruz et al., 2023). Such approaches allow students to manage essential mental effort while avoiding overload that leads to frustration. In the Philippines, however, cognitive load in mathematics learning is further intensified by curriculum demands, uneven teacher preparation, and limited access to instructional resources and technology. These conditions often result in high cognitive load among students and restrict teachers' capacity to apply evidence based instructional practices, thereby exacerbating mathematics related stress and anxiety (Zhang et al., 2023). Research indicates that multidisciplinary approaches and sustained professional development for teachers can reduce cognitive load and improve students' understanding of mathematical concepts.

Closely linked to cognitive load is cognitive dissonance in mathematics learning. Cognitive dissonance refers to a psychologically uncomfortable state that arises when individuals hold two or more conflicting beliefs, attitudes, or ideas (Zhang et al., 2023). In mathematics education, this discomfort often occurs when new concepts or problem-solving strategies conflict with students' prior knowledge or beliefs. Cognitive dissonance can either hinder or enhance learning. When unsupported, it may result in confusion and frustration, but when effectively managed, it can promote deeper understanding and conceptual change. Cognitive dissonance in mathematics learning thus refers to the discomfort students experience when they are required to revise existing frameworks to accommodate new mathematical ideas (Marbán de Frutos et al., 2024).

Evidence suggests that cognitive dissonance is particularly pronounced among students in resource limited contexts. In rural areas, where instructional materials are scarce and teachers may lack training in modern pedagogical strategies, reliance on traditional teaching approaches often heightens cognitive dissonance when students encounter unfamiliar problem types, especially in international assessments. Perez and Santos (2021) found that such instructional mismatches increase cognitive conflict and contribute to poor mathematics performance at both local and national levels. Internationally, cognitive dissonance is increasingly recognized as an essential component of productive struggle in mathematics learning. Educators are encouraged to deliberately manage this discomfort in order to build resilience and strengthen problem solving skills. Classroom metaphors such as the "sweaty brain" are used to emphasize that mental effort and temporary discomfort can lead to deeper learning and cognitive growth when students persist and reflect on their thinking (Attard, 2022).

In the Philippine context, challenges related to cognitive dissonance are compounded by inadequate instructional resources and limited teacher training. Nevertheless, instructional strategies that promote perseverance, collaborative problem solving, and real-world applications are gaining traction in local classrooms (Villanueva, 2022). Local interventions increasingly incorporate technology and differentiated instruction to provide more personalized learning experiences. These approaches help reduce mathematics anxiety by increasing learner autonomy and offering multiple pathways for engaging with mathematical content (Santos et al., 2023). Furthermore, cognitive dissonance has been deliberately used as an instructional tool to correct misconceptions by encouraging students to confront erroneous assumptions through structured reflection and collaborative learning. By fostering a growth mindset and valuing errors as learning opportunities, teachers can help students resolve dissonance and achieve deeper conceptual understanding (Zhang et al., 2023). Research further emphasizes that growth mindset oriented instructional environments enable students to manage cognitive load more effectively and reduce anxiety when learning abstract mathematical concepts (Anderson et al., 2022).

Another major factor affecting mathematics learning is mathematics anxiety, which is defined as feelings of tension, apprehension, or fear that interfere with mathematical performance. Mathematics anxiety is widely documented across basic and tertiary education and has been extensively studied by educational researchers (Ashcraft et al., 2018). Several instructional and assessment practices contribute to the development of mathematics anxiety, including time pressured testing and the use of mathematics as a form of punishment, practices that remain prevalent across school levels (Moore et al., 2019). Although mathematics anxiety can emerge early, studies indicate that it can be reduced at all stages of schooling through appropriate instruction, positive teacher attitudes, and the use of active learning strategies such as group work. Addressing teachers' own mathematics anxiety is also crucial, as it directly influences students' emotional responses to mathematics (Moore et al., 2019).

Testing situations are commonly identified as contexts in which mathematics anxiety becomes most pronounced. Students report a range of cognitive and physiological symptoms, including jumbled thoughts, memory lapses, increased heart rate, rapid breathing, and sweaty palms. Moore et al. (2020) further emphasize that persistent use of unpleasant teaching and assessment strategies contributes significantly to the spread of mathematics anxiety. These emotional responses have direct implications for student performance in large scale assessments such as the Programme for International Student Assessment and the Trends in International Mathematics and Science Study. These international assessments reveal persistent performance gaps between the Philippines and higher performing nations. Results from PISA 2018 and TIMSS 2019 indicate that Filipino students struggle to apply mathematical knowledge to real world contexts and perform poorly in higher order thinking tasks.

High performing countries in PISA and TIMSS typically employ instructional practices that manage cognitive load effectively by scaffolding learning and breaking complex tasks into manageable components (Kim et al., 2022). In contrast, Filipino students often experience cognitive dissonance when transitioning from rote based classroom instruction to the application-oriented demands of international assessments. This mismatch between teaching practices and assessment requirements leads to cognitive overload, confusion, and frustration, thereby limiting students' global competitiveness (De Guzman et al., 2022). At the national level, dense curricula and traditional teaching methods further intensify cognitive load and mathematics anxiety, particularly in assessment contexts that require critical thinking and real-world problem solving (Martinez et al., 2023). Cognitive dissonance also arises when students accustomed to rigid problem-solving methods encounter open ended tasks, a shift that has been identified as a significant contributor to the country's underperformance in international assessments (David et al., 2021).

Mathematics anxiety remains highly prevalent among Filipino students, particularly when they are required to engage in higher order thinking tasks. David et al. (2023) found that the education system's strong emphasis on standardized testing and performance rankings contributes to elevated anxiety levels, which in turn increase cognitive load during examinations such as PISA and TIMSS. In response, individual schools and educators have implemented instructional innovations including visual aids, real world examples, and project-based learning to reduce cognitive load and support conceptual understanding (Caballero et al., 2022).

Within this educational context, a mathematics learning in service training program is viewed as a vital intervention for improving teaching quality and student outcomes. Such programs aim to strengthen teachers' content knowledge, pedagogical skills, and ability to address learner challenges related to cognitive load, cognitive dissonance, and mathematics anxiety. These programs typically include interactive professional learning activities such as workshops, group discussions, micro teaching, lesson study, and training in evidence based instructional practices. They also emphasize the integration of technology, diagnostic assessment, and alignment with national and international standards such as PISA and TIMSS. Implementation strategies commonly include professional learning communities, mentoring systems, flexible training models, and continuous assessment to ensure sustained impact on instructional practices and student learning.

The present study was conducted in public secondary schools in the Province of Iloilo during the school year 2024 to 2025. It sought to determine the levels of cognitive load and cognitive dissonance in mathematics learning, as well as mathematics anxiety, among Grade 9 students, in order to identify challenges affecting mathematics performance and inform the development of educational reforms. The study was anchored in cognitive load theory proposed by Sweller, cognitive dissonance theory developed by Festinger, constructivist learning theory advanced by Piaget and Vygotsky, and self-efficacy theory articulated by Bandura. These theoretical frameworks emphasize the management of mental effort, the productive resolution of cognitive conflict, the active construction of knowledge through interaction, and the role of self-belief in learning. Findings of the study were interpreted through these theoretical lenses to examine the relationships among cognitive load and cognitive dissonance as independent variables and mathematics anxiety as the dependent variable, and to determine how these factors interact and influence one another in the mathematics learning experiences of Grade 9 students.

Statement of the problem

This study aimed to determine the building of resilience in mathematics through innovative training focused on cognitive load, cognitive dissonance, and mathematics anxiety among students in the Province of Iloilo during the school year 2024-2025. Specifically, it sought to examine the levels and interrelationships of these cognitive and affective factors as a basis for identifying predictors of mathematics anxiety and for developing an appropriate educational deliverable grounded in the findings of the investigation.

1. What is the level of cognitive load in mathematics learning when considered as a whole and when examined in terms of intrinsic, extraneous, and germane loads?
2. What is the level of cognitive dissonance in mathematics learning among students?
3. What is the level of mathematics anxiety experienced by students?
4. Is there a significant difference in mathematics anxiety among students when grouped according to their levels of cognitive load in mathematics learning?
5. Is there a significant difference in mathematics anxiety among students when grouped according to their levels of cognitive dissonance in mathematics learning?
6. Are there significant relationships among cognitive load, cognitive dissonance in mathematics learning, and mathematics anxiety of students?
7. Are cognitive load and cognitive dissonance in mathematics learning significant predictors of mathematics anxiety among students?
8. What deliverable can be developed based on the findings of the study?

METHODOLOGY

This study employed a mixed methods explanatory sequential research design to determine the levels of cognitive load, cognitive dissonance, and mathematics anxiety of Grade 9 students during the school year 2024 to 2025. The explanatory sequential design began with a quantitative phase followed by a qualitative phase intended to explain and deepen the quantitative findings (Creswell, 2015). Mixed methods research was selected because it constitutes a distinct methodology with its own philosophical assumptions and procedures for collecting and analyzing data from multiple sources within a single study (Creswell & Plano Clark, 2015). The quantitative component utilized a survey correlational design, which follows a deductive approach aimed at examining existing theories by measuring variables and testing relationships among them (Levy, 2017). This approach emphasizes objectivity, neutrality, and the generation of statistical knowledge from a large sample and is appropriate when the primary purpose of the study is explanation and evaluation. Correlational analysis was applied to determine patterns of association among cognitive load, cognitive dissonance, and mathematics anxiety, including the strength and direction of relationships using correlation coefficients (Creswell, 2013; Creswell et al., 2014).

To complement the quantitative findings, the qualitative component employed focus group discussion as a method of inquiry. Qualitative research follows an inductive approach that seeks to generate meaning and understanding from participants' experiences, beliefs, and perceptions (Leavy, 2014). Focus group discussion was selected because it allows a researcher to assemble participants to discuss a specific topic through moderated interaction, drawing from their collective experiences and attitudes (Zabala & Mukherjee, 2017). In this study, interviews and a focus group discussion interview guide were used to collect qualitative data in order to gain deeper insight into students' experiences of cognitive dissonance and mathematics learning. The focus group discussion involved Grade 9 students from the districts in the Province of Iloilo and was designed to explain and contextualize the quantitative results. Qualitative data gathered from the discussion were analyzed using thematic analysis to identify recurring patterns and themes.

The participants of the study consisted of 395 Grade 9 students selected from a total population of 31,682 Grade 9 students enrolled in public secondary schools across the Province of Iloilo. The sample size was determined using the Taro Yamane formula with a five percent margin of error. Proportionate stratified sampling was employed to ensure that the sample from each district was proportional to the size of the district population, thereby ensuring equitable representation across strata (Lauren Thomas, 2020). Systematic sampling was further applied within each stratum by selecting every nth student from an ordered population list, beginning from a randomly selected starting point, to achieve an evenly distributed and representative sample (Creswell, 2018). The distribution of respondents across the five districts was as follows: District I had a population of 5,479 students with a sample of 68 respondents; District II had 5,939 students with a sample of 74 respondents; District III had 7,199 students with a sample of 90 respondents; District IV had 4,932 students with a sample of 62 respondents; and District V had 8,133 students with a sample of 101 respondents, yielding a total sample of 395 respondents. In addition to the survey respondents, ten Grade 9 students from different public secondary schools across the province participated in the focus group discussion to provide qualitative data.

Data were collected using adopted checklist questionnaires and a researcher made interview guide. Cognitive load in mathematics learning was measured using a twenty-four-item checklist adapted from the Student Conceptual Scale developed by Dong et al. (2022). The instrument consisted of three components, with items one to eight measuring intrinsic load, items nine to seventeen measuring extraneous load, and items eighteen to twenty-four measuring germane load. Responses were interpreted using a five-point scale, where scores from 4.21 to 5.00 indicated a very high level described as highly developed cognitive load, scores from 3.41 to 4.20 indicated a high level described as somewhat developed, scores from 2.61 to 3.40 indicated a moderate or average level, scores from 1.81 to 2.60 indicated a low or weak level, and scores from 1.00 to 1.80 indicated a very low or very weak level.

Cognitive dissonance in mathematics learning was measured using a sixteen-item checklist questionnaire adapted from the study Impact of Students Attitude on Mathematics Performance Among Public Secondary Schools Students by Montanya (2018). The same five-point scale was used for interpretation, where scores from 4.21 to 5.00 indicated a very high level of cognitive dissonance, scores from 3.41 to 4.20 indicated a high level, scores from 2.61 to 3.40 indicated a moderate level, scores from 1.81 to 2.60 indicated a low level, and scores from 1.00 to 1.80 indicated a very low level. Mathematics anxiety was measured using a nineteen-item checklist questionnaire adapted from the Mathematics Anxiety Questionnaire developed by May (2009). The interpretation of mathematics anxiety followed the same scale, with scores ranging from very low to very high levels of anxiety based on the numerical ranges specified.

Prior to data collection, the researcher initiated preliminary communication through social media platforms to determine the number of Grade 9 students enrolled in public secondary schools across the province. Upon approval of the adopted questionnaires and the focus group discussion guide, a formal request letter was submitted to the Schools Division Superintendent of the Division of Iloilo and was duly noted and endorsed by the Dean of the Graduate School of Filamer Christian University. After permission was granted, the instruments were submitted to a panel of experts for content validation. A pilot test was conducted among thirty randomly selected Grade 9 students from Cabalic National High School to determine the reliability of the instruments. Following validation and pilot testing, communication letters were sent to school principals of the participating schools, after which the researcher personally administered and retrieved the questionnaires. Completed responses were tallied, encoded, and submitted to a statistician for analysis using the Statistical Package for the Social Sciences software.

For the qualitative phase, a focus group discussion was conducted on January 31, 2025 at Estancia National High School. Two Grade 9 students from each district were selected to participate, resulting in a total of ten participants. Invitation letters were sent and approved, and participants confirmed their willingness to join the discussion. The session was facilitated by an external moderator to ensure objectivity and effective discussion management. The focus group discussion began with an introduction and icebreaker activity, followed by open ended questions aligned with the objectives of the study. Social media platforms were utilized to support recording, documentation, and organization of responses. The discussion was transcribed verbatim, and qualitative data were analyzed thematically to generate meaningful interpretations related to cognitive load, cognitive dissonance, and mathematics anxiety.

Ethical considerations were strictly observed throughout the research process. All participants were fully informed of the purpose of the study, the benefits of participation, and their rights, including voluntary participation and the option to withdraw at any time without consequence. Informed consent was obtained prior to data collection. Confidentiality and anonymity were assured for both survey responses and focus group discussion data, and all collected information was securely stored and used solely for academic purposes.

Data analysis involved both descriptive and inferential statistical techniques. Mean and standard deviation were used to describe the levels of cognitive load, cognitive dissonance in mathematics learning, and mathematics anxiety among Grade 9 students in the Province of Iloilo. Analysis of variance was employed to determine significant differences in mathematics anxiety across levels of cognitive load and cognitive dissonance. Pearson correlation analysis was used to examine the relationships among cognitive load, cognitive dissonance, and mathematics anxiety. Regression analysis was conducted to identify significant predictors of mathematics anxiety from cognitive load and cognitive dissonance variables. All inferential statistical tests were conducted at a five percent level of significance to ensure that the findings were not due to random chance.

RESULTS AND DISCUSSION

This section presents and discusses the findings derived from the responses of 395 Grade 9 students enrolled in public secondary schools in the Province of Iloilo during the school year 2024–2025. The study employed a mixed methods explanatory sequential design, wherein quantitative data were gathered using three adopted checklist questionnaires on cognitive load, cognitive dissonance, and mathematics anxiety, followed by qualitative data collected through a focus group discussion involving ten students from different school districts. The respondents were selected using proportionate stratified sampling and systematic sampling, ensuring representation across five districts. Descriptive statistics, including mean and standard deviation, were used to determine the levels of the variables, while inferential analyses such as analysis of variance, Pearson product moment correlation, and multiple linear regression were conducted at a five percent level of significance. The qualitative findings from the focus group discussion were used to validate, explain, and enrich the quantitative results. The discussion that follows is anchored on the objectives of the study and interpreted in light of relevant theories and empirical literature.

The 395 respondents represented five districts in the Province of Iloilo, drawn proportionately from a total Grade 9 population of 31,682 students. District I contributed 68 respondents out of 5,479 students, District II contributed 74 respondents out of 5,939 students, District III contributed 90 respondents out of 7,199 students, District IV contributed 62 respondents out of 4,932 students, and District V contributed 101 respondents out of 8,133 students. This proportional distribution ensured that the results reflected diverse instructional contexts and learning environments within the province, providing a sound basis for examining students' cognitive and emotional experiences in mathematics learning.

Cognitive load in mathematics learning

The level of cognitive load in mathematics learning among the Grade 9 students was found to be high, with an overall mean of 3.45 and a standard deviation of 0.36. When examined by component, intrinsic load registered a high level with a mean of 3.50 and a standard deviation of 0.54, extraneous load registered a moderate level with a mean of 3.21 and a standard deviation of 0.59, and germane load registered a high level with a mean of 3.65 and a standard deviation of 0.49. These results indicate that students generally experience substantial mental effort when learning mathematics, particularly due to the inherent complexity of the subject matter and the cognitive processes required to understand and integrate new concepts. A high intrinsic load suggests that mathematical tasks are perceived as challenging and demand considerable effort, especially for students who may lack sufficient prior knowledge or foundational skills. The high germane load further suggests that students are engaging in deeper cognitive processing, such as problem solving, schema construction, and meaningful integration of new information. Meanwhile, the moderate extraneous load implies that although instructional design and external factors may present some difficulties, these factors do not overwhelmingly disrupt learning.

The qualitative data strongly supported these findings. During the focus group discussion, students consistently described experiencing high cognitive load when confronted with complex problems and lengthy procedures. One participant explained, "Kong ererate ko ang aking cognitive load sa meta sa mathematika mula 1 hanggang 5. Ang ererate ko ay 4 may mga pagkakataon na tumataas ang cognitive load," translated as "My cognitive load in mathematics is high because there is a time when my cognitive load increases if the problems require lengthy procedure or other concepts that needed to combine." Another participant stated, "Ang cognitive ko sa math nobo lang kay may ara time nga nabudlayan," translated as "My cognitive load in mathematics tends to be consistently high, particularly when faced with complex problems that require multiple steps, advanced reasoning, or unfamiliar concepts." Similarly, another student shared, "Ang cognitive load ko sa mathematics ay taas kay kong kis a if I am facing math problems," translated as "My cognitive load in mathematics is high because sometimes, when I am facing math problems, I find them difficult. When I try to think of the answers, my cognitive load increases because I still need to perform operations, focus, and give extra attention in order to solve them." Another discussant added, "Ang cognitive ko sa math ay taas lang kay may ara nga time nga gakadulaan ko, kakabudlayan ko mag intsindi," translated as "My cognitive load in math is high because there are times when I get lost and struggle to understand, especially when the equations are difficult and there are many things to solve."

These experiences align with cognitive load theory, which explains that learning becomes more difficult when learners are required to process multiple interacting elements simultaneously within the limited capacity of working memory. As emphasized by Sweller (2022), cognitive overload may occur when learners attempt to solve complex problems without fully understanding the underlying principles. Furthermore, Gupta and Zheng (2020) noted that task difficulty significantly increases intrinsic load, and when coupled with inefficient instructional design, extraneous load may also rise, further hindering learning.

Cognitive dissonance in mathematics learning

The level of cognitive dissonance in mathematics learning among the respondents was found to be moderate, with a mean of 3.30 and a standard deviation of 0.39. This indicates that students experience a noticeable degree of psychological discomfort arising from conflicting beliefs, such as confidence in their preparation versus doubt about their correctness. A moderate level of cognitive dissonance suggests that students frequently encounter internal conflict when learning mathematics, particularly when responding to questions, solving unfamiliar problems, or participating in oral recitations.

The focus group discussion provided strong qualitative support for this finding. One participant stated, "Kong e rate ko ang akon nga cognitive dissonance sa math Seguro mabutang ako sa 3," translated as "Cognitive dissonance arises when I'm certain I know the answer, yet doubt creeps in because I wonder if my understanding is wrong, which is why I rate my confidence a 3." Another participant explained, "E rate ko akon cognitive dissonancane sa math sa 3 o moderate kay damo gid ya nga time nga gaduha duha," translated as "I rate my cognitive dissonance in math as a 3, or moderate, because there were many times I doubted my answers, especially when I was being called on." Similarly, another discussant shared, "E rate ko 3 kay kis a ga doubt ko sa akon nga self," translated as "I would rate it a 3 because I often find myself doubting my problem-solving abilities and feeling uncertain about my skills in math." Another participant reflected, "Kong e rate ko ang akon cognitive dissonance mula 1 asta 5, Seguro ara ko sa 3 kay kong kis a nabatyagan ko ang mga mental tension," translated as "If I were to rate my cognitive dissonance from 1 to 5, I would probably be at 3. Sometimes, I feel mental tension when there is a conflict in my beliefs about myself." A final discussant noted, "Kong e rate ko ang akon cognitive dissonance sa math nga sa scale nga 1 to 5, e rate ko in sa 3 kis a gakabatyagan ko ang mental tension," translated as "If I were to rate my cognitive dissonance in math on a scale of 1 to 5, I would rate it a three. Sometimes, I feel mental tension when there is a conflict in my beliefs."

These findings are consistent with Balaman (2020), who reported that students' emotional reactions to cognitive dissonance in mathematics often include discomfort, anxiety, confusion, and reduced self-confidence. Odiri (2023) further explained that such dissonance may lead to avoidance behaviors, hesitation, and negative attitudes toward mathematics as students attempt to minimize psychological discomfort.

Mathematics anxiety of Grade 9 students

The level of mathematics anxiety among the Grade 9 students was found to be high, with a mean of 3.63 and a standard deviation of 0.50. This indicates that many students experience intense fear, nervousness, and worry when engaging with mathematics, particularly in evaluative situations. High mathematics anxiety suggests that students may struggle to focus, experience mental blocks, and exhibit physiological symptoms such as increased heart rate and sweating, which interfere with effective learning and problem solving.

The qualitative findings strongly reinforced this result. One participant stated, “Nakulbaan ko, kag high akon math anxiety,” translated as “I have a high level of math anxiety because of fear not to get the right answer.” Another shared, “Ang math anxiety ko ay high ang nabatyagan ko ay nahadlok ko,” translated as “I have a high level of math anxiety because of fear of not answering questions during oral recitation.” Another explained, “Ang kulba ko sa math or ang ginakahadlukan ko is ang sa magsala sa mga pamangkot,” translated as “What makes me nervous about math is making mistakes when answering my math teacher's questions.” Another participant noted, “My math anxiety is high ser kay ang math anxiety or kulba ko sa math halin sa self-doubt,” translated as “My math anxiety is high because my anxiety or fear of math comes from self-doubt and the fear of making mistakes.”

These findings align with Jethwani (2023), who emphasized that students with high mathematics anxiety often doubt their abilities, leading to hesitation and reduced confidence in solving mathematical problems.

Differences in mathematics anxiety by cognitive load and cognitive dissonance

Analysis of variance revealed no significant difference in mathematics anxiety among the levels of cognitive load in mathematics learning, with an F value of 0.897 and a significance value of 0.443. This indicates that students reported similar levels of anxiety regardless of whether their cognitive load was high, moderate, or low. Similarly, no significant difference was found in mathematics anxiety among the levels of cognitive dissonance, with an F value of 1.686 and a significance value of 0.170. These findings suggest that mathematics anxiety is not significantly differentiated by students’ levels of cognitive load or cognitive dissonance.

Focus group discussion participants strongly supported these results. One student stated, “Ang math anxiety nagatutok sa emotional and psychological na pa nga emotion,” translated as “Math anxiety focuses on the emotional and psychological aspect of emotions.” Another shared, “Bisan mataas okon manubo gyapon ang cognitive load ser kay maskin mataas okon manubo ara gaypon ang math anxiety,” translated as “Whether the cognitive load is high or low, the math anxiety is still there.” These findings conform with Dowson (2019), who noted that mathematics anxiety is closely related to reduced confidence and emotional responses rather than task difficulty alone.

Relationships and predictive effects among variables

Pearson correlation analysis revealed no significant relationship between cognitive load and cognitive dissonance, with r equal to 0.058 and p equal to 0.253, and no significant relationship between cognitive load and mathematics anxiety, with r equal to minus 0.058 and p equal to 0.250. However, a significant relationship was found between cognitive dissonance and mathematics anxiety, with r equal to minus 0.104 and p equal to 0.039. This very weak negative correlation indicates that higher levels of cognitive dissonance were associated with lower levels of mathematics anxiety.

Multiple linear regression analysis further showed that the overall model was not significant, with F equal to 2.675, p equal to 0.070, and R squared equal to 0.013. Cognitive load was not a significant predictor of mathematics anxiety, with p equal to 0.299, while cognitive dissonance emerged as a significant predictor, with p equal to 0.046 and a regression coefficient of minus 0.129. This indicates that cognitive dissonance contributed 12.9 percent in predicting mathematics anxiety.

Focus group participants largely agreed with this interpretation. One stated, “Sa akon nga pag intinde ser, may punto nga indi man gid makapredict ang cognitive load sang math anxiety,” translated as “I think it makes sense that cognitive load doesn’t predict math anxiety.” Another explained, “Gapati ako ser nga ang cognitive dissonance makapredict sang math anxiety,” translated as “I agree that cognitive dissonance can predict math anxiety.”

These findings align with Sweller (2018), Süren and Kandemir (2020), and Brewster and Miller (2023), who emphasized that mathematics anxiety is primarily driven by emotional factors such as self-doubt and fear rather than cognitive effort alone.

Synthesis

In summary, the findings demonstrate that Grade 9 students experience high cognitive load and high mathematics anxiety, alongside a moderate level of cognitive dissonance. While cognitive load does not significantly influence mathematics anxiety, cognitive dissonance plays a subtle yet meaningful role, with higher dissonance associated with lower anxiety. These results highlight the importance of addressing emotional and metacognitive dimensions of mathematics learning and provide strong empirical support for the development of an in-service training program aimed at helping teachers manage cognitive load, guide students through cognitive dissonance, and reduce mathematics anxiety in secondary school classrooms.

CONCLUSION

The present study was conducted to determine the levels of cognitive load, cognitive dissonance in mathematics learning, and mathematics anxiety among Grade 9 students in the Province of Iloilo during the school year 2024 to 2025, as well as to examine the differences, relationships, and predictive effects among these variables as a basis for developing an appropriate educational output. The investigation employed a mixed methods approach that integrated quantitative and qualitative procedures. A total of 395 Grade 9 students from 32 public secondary schools across the province participated in the study, with the sample size determined using the Taro Yamane formula and selected through stratified sampling to ensure proportional representation of students from different schools, backgrounds, and contexts. Quantitative data were gathered using three adopted checklist questionnaires, namely the Cognitive Load Student’s Conceptual Scale, the Cognitive Dissonance questionnaire from Impact of Students Attitude on Mathematics Performance Among Public Secondary Schools Students, and the Mathematics Anxiety Questionnaire, while qualitative data were obtained through a focus group discussion using a researcher made interview guide. Descriptive statistics such as mean, frequency, percentage, and standard deviation were used to describe the data, while analysis of variance, Pearson product moment correlation, and regression analysis were employed for inferential analysis at a 0.05 level of significance, with data processed using the Statistical Package for the Social Sciences.

The findings showed that the level of cognitive load in mathematics learning among the students as a whole was high, with high levels recorded for both intrinsic and germane cognitive load and a moderate level recorded for extraneous cognitive load. These results indicate that students perceived mathematics learning as cognitively demanding due to the inherent complexity of mathematical content while also actively engaging in meaningful cognitive processing. The moderate level of extraneous load suggests that although instructional design and external factors posed some challenges, these were not excessive enough to severely hinder learning. The study further revealed that the level of cognitive dissonance in mathematics learning among the students was moderate, reflecting the presence of mental discomfort arising from conflicting beliefs, self-doubt, and uncertainty when engaging with mathematical tasks, particularly during assessments and oral recitations. This level of dissonance suggests that students frequently experienced cognitive conflict but not to an extent that led to extreme confusion or disengagement. In addition, the level of mathematics anxiety among the students was found to be high, indicating that many students experienced intense fear, nervousness, and worry when dealing with mathematics, which affected their confidence, focus, and overall engagement with the subject.

Inferential analyses demonstrated that there was no significant difference in mathematics anxiety among the levels of cognitive load in mathematics learning, indicating that students experienced similar levels of anxiety regardless of whether their cognitive load was high, moderate, or low. Similarly, there was no significant difference in mathematics anxiety among the levels of cognitive dissonance in mathematics learning, suggesting that variations in cognitive dissonance did not significantly differentiate students' anxiety levels. Correlational analysis further revealed that there was no significant relationship between cognitive load and mathematics anxiety, and no significant relationship between cognitive load and cognitive dissonance. However, a significant relationship was found between cognitive dissonance and mathematics anxiety, characterized by a very weak negative correlation, indicating that higher levels of cognitive dissonance were associated with lower levels of mathematics anxiety. Regression analysis supported this finding by showing that cognitive load was not a significant predictor of mathematics anxiety, whereas cognitive dissonance emerged as a significant predictor. These results indicate that while mental effort alone does not directly influence mathematics anxiety, students' engagement with and resolution of cognitive conflict may play a meaningful role in reducing anxiety.

Based on the synthesis of quantitative and qualitative findings, the study concludes that mathematics learning among Grade 9 students in the Province of Iloilo is characterized by high cognitive demands and high levels of anxiety, alongside a moderate level of cognitive dissonance. Cognitive load, although high, does not significantly influence mathematics anxiety, suggesting that anxiety is not merely a function of task difficulty or mental effort. Instead, cognitive dissonance appears to have a nuanced role, as productive engagement with cognitive conflict may help reduce anxiety when students are supported appropriately. These conclusions underscore the importance of addressing both cognitive and affective dimensions of mathematics learning through well designed instructional strategies and supportive learning environments.

In light of these conclusions, the study recommends the development and implementation of an In-Service Training Program designed to help teachers assist students in managing cognitive load, navigating cognitive dissonance, and reducing mathematics anxiety. Such a program should equip teachers with strategies to reduce extraneous cognitive load through clear, organized, and step by step instruction while maintaining intrinsic and germane demands that promote deep understanding. It should also emphasize instructional practices that help students manage cognitive dissonance productively, including scaffolding, reflective activities, and the promotion of a growth mindset. Furthermore, the program should incorporate anxiety reducing strategies such as confidence building activities, emotionally supportive teaching approaches, normalization of mistakes, mindfulness practices, and the integration of real-life applications of mathematics. Beyond classroom instruction, the findings highlight the need for school leaders to support teachers through professional development and collaborative initiatives, for policymakers to prioritize programs that address both cognitive and emotional aspects of learning, for parents to reinforce positive attitudes toward mathematics at home, and for future researchers to further investigate cognitive dissonance across subject areas and its long term effects on academic performance and student well-being. Through these combined efforts, mathematics classrooms can become more supportive, inclusive, and effective environments that foster both cognitive competence and emotional resilience among learners.

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