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Canonical Correlation Analysis (CCA) Between Student Dispositions and Mathematics Performance in Technology-Enhanced Collaborative Learning Environments

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Abstract

This study explored the multivariate relationship between student dispositions—namely attention span, student engagement, and learning anxiety—and mathematics performance, both perceived and actual, within technology-enhanced collaborative learning environments. A quantitative research design utilizing Canonical Correlation Analysis was employed. The sample consisted of 277 Senior High School students from different academic strands at the Universidad de Zamboanga. Data were gathered through validated survey instruments demonstrating high reliability (Cronbach's alpha = 0.981) together with official mathematics grade records and were analyzed using descriptive statistics and Canonical Correlation Analysis in SPSS. Descriptive findings revealed consistently high mean ratings across all dispositional indicators, with a grand mean of 3.62, indicating positive student attitudes toward collaborative and technology-integrated mathematics learning. Perceived mathematics performance likewise received a high grand mean of 3.66. Actual grades averaged 89.04, with most students falling within the Outstanding and Very Satisfactory ranges. The Canonical Correlation Analysis produced a strong first canonical correlation of 0.905 that was statistically significant ($p < .001$). Learning anxiety emerged as the most influential dispositional variable, while perceived mathematics performance exhibited a markedly stronger canonical loading than final grades. These results highlight the psychological and experiential dimensions of performance and demonstrate that how students feel and behave during collaborative technology-supported tasks is more closely linked to their sense of success than official grades alone. The study concludes that fostering positive dispositions through technology-supported group activities can enhance students' confidence and effectiveness in mathematics. Educators are therefore encouraged to integrate collaborative digital tools, promote peer interaction, create supportive learning climates, incorporate student reflections, and provide teacher training on technology use and dispositional awareness. The research aligns with Sustainable Development Goal 4 (Quality Education) by identifying practical means to strengthen inclusive and effective secondary mathematics learning. It also advances educational and digital sustainability by informing institutional strategies that build resilient learner dispositions and improve academic outcomes in technology-enhanced collaborative settings.

Keywords: Attention Span; Canonical Correlation Analysis; Collaborative Learning; Learning Anxiety; Mathematics Performance; Senior High School; Student Dispositions; Student Engagement; Technology-Enhanced Learning

1. Introduction

Technology-enhanced collaborative learning provides social and affective support that can promote sustained attention, behavioral and cognitive engagement, and reduced situational learning anxiety (Eidlin-Levy et al., 2023; Yang & Chen, 2024). Interactive platforms and digital resources can personalize instruction, facilitate peer collaboration, and reduce cognitive load, particularly in challenging subjects such as mathematics (Feng et al., 2021; Sofroniou et al., 2025). Digital platforms, interactive software, and gamified applications can also improve focus, reduce cognitive friction, and support personalized learning pathways during complex mathematical problem-solving activities (Paliwal & Patel, 2025; Wardat et al., 2023). Gamified environments and mobile learning applications further encourage intrinsic motivation and active participation. By providing interactive and low-stakes opportunities for exploration, these approaches may help reduce the negative effects of mathematics anxiety (Ní Shé et al., 2023; Palancı & Turan, 2021). Collaborative learning supported by digital tools may also strengthen students' sense of belonging, motivation, and willingness to take intellectual risks.

Related literature emphasizes three interconnected themes: student attention, engagement, and learning anxiety. Technology-supported group activities can help students sustain attention by providing interactive tasks and opportunities for peer participation. They can also strengthen engagement by making mathematics learning more collaborative, motivating, and responsive to students' learning needs. Learning anxiety is particularly important because students' emotional experiences may influence their confidence, participation, and perceived competence in mathematics. Research indicates that students' perceptions of their own academic performance may be more closely related to their emotional and behavioral dispositions than to their actual grades (Ulum & Küçükdanacı, 2022; Zhu et al., 2024). This suggests that perceived mathematics performance should be examined alongside objective academic results when assessing students' experiences in technology-enhanced learning environments.

Globally, STEM and secondary mathematics education have increasingly adopted collaborative approaches and digital technologies to support achievement and engagement. Interactive learning platforms, mobile applications, gamified resources, and other digital tools are used to improve students' focus, motivation, problem-solving, and participation (Feng et al., 2021; Paliwal & Patel, 2025; Wardat et al., 2023). These approaches are particularly relevant to mathematics education because they can provide alternative ways for students to understand difficult concepts and manage anxiety. Within the context of Senior High School education, collaborative learning supported by technology may help students develop confidence and positive learning behaviors. Peer-assisted learning can promote academic achievement and engagement, while computer-supported collaborative learning can strengthen peer interaction and learning outcomes (Dodongan, 2021; Kong, 2021; Sol et al., 2021). However, the relationship among student dispositions, perceived mathematics performance, and actual mathematics grades requires further examination in specific educational settings.

The study is conceptually based on the view that mathematics performance is shaped not only by academic knowledge but also by students' attention, engagement, emotional experiences, and participation in the learning process. Technology-enhanced collaborative learning provides an environment in which these factors interact through peer support, digital resources, and shared problem-solving activities. The study therefore examines two related sets of variables. The first set consists of student dispositions, specifically attention span, student engagement, and learning anxiety. The second set consists of mathematics performance indicators, namely perceived mathematics performance and actual mathematics grades. Canonical Correlation Analysis (CCA) is used to determine the multivariate relationship between these two sets.

Existing research has established the value of technology-enhanced and collaborative learning for mathematics motivation, engagement, and achievement. However, less attention has been given to the simultaneous relationship among attention span, student engagement, learning anxiety, perceived mathematics performance, and actual mathematics grades within one analytical framework. Previous findings also suggest that students' perceptions of their mathematics performance may be more strongly connected to their dispositions than their recorded grades (Ulum & Küçükdanacı, 2022; Zhu et al., 2024). To address this gap, the present study uses Canonical Correlation Analysis (CCA) to examine the combined relationship between student dispositions and mathematics performance among Senior High School students in a technology-enhanced collaborative learning environment. The study specifically determines the levels of attention span, student engagement, learning anxiety, perceived mathematics performance, and mathematics grades, as well as the significance of the relationship between the two variable sets.

The study directly supports SDG 4 – Quality Education by examining learning conditions that may improve student engagement, confidence, participation, and mathematics performance. Its focus on technology-enhanced collaborative learning also contributes to educational and digital sustainability by identifying ways to use digital tools in support of meaningful and inclusive mathematics instruction. The study is also related to SDG 3 – Good Health and Well-Being because it considers learning anxiety and the emotional experiences of students. By examining how collaborative and technology-supported environments relate to students' confidence and comfort in mathematics learning, the study recognizes the importance of affective well-being in educational achievement.

The study contributes primarily to educational, technological, and psychosocial sustainability. Its educational contribution lies in supporting learning approaches that promote engagement, collaboration, and mathematics achievement. Its technological contribution involves examining how digital tools can be integrated into collaborative instruction to support attention, participation, and problem-solving. The study also contributes to psychosocial and institutional sustainability by emphasizing supportive learning environments that address anxiety and encourage student confidence. By connecting student dispositions with both perceived and actual mathematics performance, the research provides a basis for developing learning practices that are academically effective, emotionally supportive, and sustainable within technology-integrated educational settings.

2. Material and methods

2.1 Research Design

The study used a quantitative, correlational research design with Canonical Correlation Analysis (CCA). This approach was applied to determine the relationship between two sets of variables: student dispositions, consisting of attention span, student engagement, and learning anxiety; and mathematics performance, consisting of perceived mathematics performance and final mathematics grades. The design enabled the researchers to examine the combined relationship between these variables in a technology-enhanced collaborative learning environment.

2.2 Locale of the Study

The study was conducted at the Universidad de Zamboanga Senior High School. The research focused on students from different academic strands who participated in mathematics learning activities supported by collaborative approaches and digital technologies.

2.3 Respondents of the Study

The respondents were 277 Senior High School students enrolled at the Universidad de Zamboanga. They represented various academic strands, including Accountancy, Business, and Management (ABM), General Academic Strand (GAS), Humanities and Social Sciences (HUMSS), and Science, Technology, Engineering, and Mathematics (STEM). The respondents provided information about their attention span, engagement, learning anxiety, perceived mathematics performance, and actual mathematics grades.

2.4 Sample and Sampling Procedure

The study included 277 Senior High School students from the Universidad de Zamboanga. The respondents were selected from the available Senior High School population across the different academic strands. The sample included students whose mathematics performance could be assessed through both their survey responses and recorded final grades.

2.5 Research Instrument

Data were collected using validated survey instruments and the respondents' mathematics grade records. The survey measured three student dispositions: attention span, student engagement, and learning anxiety. It also assessed students' perceived mathematics performance in technology-enhanced collaborative learning activities. The instrument obtained a Cronbach's alpha of 0.981, indicating high internal consistency. Actual mathematics performance was determined using the students recorded final grades.

2.6 Data Gathering Procedure

Before data collection, permission was sought from the school administration. The respondents were informed about the purpose and procedures of the study, and their participation was voluntary. After obtaining informed consent, the validated survey instruments were administered to the selected Senior High School students. The researchers also obtained the respondents' mathematics grade records for use as an actual performance indicator. The collected data were treated confidentially and used solely for academic research purposes.

2.7 Data Analysis Techniques

The collected data were organized, coded, and analyzed using SPSS. Descriptive statistics were used to determine the levels of student dispositions and mathematics performance. Means were computed for attention span, student engagement, learning anxiety, and perceived mathematics performance, while frequency distributions were used to describe the respondents' mathematics grade intervals. Canonical Correlation Analysis (CCA) was then used to examine the multivariate relationship between the set of student dispositions and the set of mathematics performance indicators. The analysis used canonical correlations, Wilks' Lambda, canonical coefficients, canonical loadings, cross-loadings, and variance estimates to interpret the relationships between the two variable sets.

2.8 Ethical Considerations

The study observed ethical principles concerning respect for participants, research integrity, and confidentiality. The respondents were informed of the study's purpose, procedures, and voluntary nature through an informed consent process. They were assured that their responses would remain confidential and would be used only for academic research. No personally identifiable information was collected, and the respondents were informed of their right to withdraw from the study at any time without penalty. The research process involved no deception or coercion and followed standards of honesty, fairness, and transparency.

3. Results and Discussion

3.1 Descriptive Findings on Student Dispositions and Mathematics Performance

3.1.1 Demographic Profile of the Respondents

The respondents were predominantly female (61.01%), with males comprising 34.66% and LGBTQ+ community members 4.33%. In terms of academic strand, nearly half of the students (46.93%) belonged to STEM, followed by HUMSS (27.08%), GAS (19.13%), and ABM (6.86%). Ethnically, most respondents identified as Tausug (62.09%), while the remainder were Zamboangueño (21.30%), Tagalog (6.14%), Bisaya (6.50%), and other minority tribes (3.97%). This demographic profile indicates a student population with a strong orientation toward mathematics, particularly given the large proportion from the STEM strand. The predominance of a shared cultural background may also facilitate collaborative learning experiences and openness to technology-enhanced instruction, as group cohesion and cultural familiarity can support peer interaction and collective engagement in classroom tasks.

3.1.2 Levels of Student Dispositions

Students generally reported positive dispositions toward learning mathematics in a technology-enhanced collaborative environment. All three disposition indicators—attention span, student engagement, and learning anxiety—received mean scores above 3.50, falling within the "Agree" category and indicating a high level of positive response. Learning anxiety obtained the highest mean (3.67), followed by student engagement (3.61) and attention span (3.59), yielding an overall grand mean of 3.62. These findings suggest that students feel relatively comfortable, confident, and supported when learning mathematics through collaborative activities aided by digital tools. The elevated learning anxiety score reflects reduced stress and greater confidence in group-based, technology-supported settings, which may mitigate the pressure often associated with individual performance in mathematics. Such results align with literature indicating that technology-enhanced collaborative environments provide social and affective scaffolding that can reduce situational learning anxiety and promote positive dispositional orientation (Barroso et al., 2021; Demedts et al., 2022; Eidlin-Levy et al., 2023; Yang & Chen, 2024). The supportive nature of group work and interactive educational technologies likely contributes to students' willingness to engage, sustain attention, and approach mathematics with less apprehension (Dodongan, 2021; Kong, 2021; Sol et al., 2021).

3.1.3 Levels of Mathematics Performance

Students also rated their mathematics performance positively in the collaborative, technology-integrated environment. The perceived mathematics performance indicators yielded a grand mean of 3.66, categorized as "High." The highest-rated statement was that collaborative learning activities improved their overall performance in mathematics (M = 3.77), followed closely by the belief that their mathematics grades improved as a result of participating in collaborative learning experiences (M = 3.76). Other indicators—such as understanding concepts better with technology, enhanced problem-solving ability when working with classmates through technology, and increased confidence in math performance—also received means in the "Agree" range. These results imply that students perceive collaborative, technology-supported mathematics learning as beneficial to their understanding, confidence, and overall performance. The strong agreement that group-based activities and digital tools improve performance supports the view that such environments enable students to feel more competent and capable in mathematics. This perception is consistent with research showing that interactive platforms, digital resources, and peer collaboration can personalize learning, reduce cognitive load, and enhance motivation and achievement in mathematics (Feng et al., 2021; Sofroniou et al., 2025; Paliwal & Patel, 2025; Wardat et al., 2023). Furthermore, the emphasis on improved confidence and perceived performance echoes findings that student perceptions of their academic success are closely tied to their emotional and behavioral dispositions in supportive, technology-rich learning contexts (Ulum & Küçükdanacı, 2022; Zhu et al., 2024).

3.1.4 Actual Mathematics Grades

The distribution of actual mathematics grades showed that a large majority of students achieved high-performance levels. More than half of the respondents (50.54%) obtained grades in the "Outstanding" range (90–100), while 32.13% earned grades in the "Very Satisfactory" range (85–89), resulting in a combined 82.67% of students performing at these two highest levels. Smaller proportions fell into the "Satisfactory" (10.83%), "Fairly Satisfactory" (6.14%), and "Did not meet Expectation" (0.36%) categories. The overall mean grade was 89.04, with a standard deviation of 5.85, indicating a relatively consistent level of academic achievement across the

sample. This pattern of high actual performance aligns with the students' positive dispositions and favorable perceptions of their mathematics performance. The convergence of strong grades with high self-reported confidence and engagement suggests that the technology-enhanced, collaborative learning setup may meaningfully contribute to academic success in mathematics. These findings resonate with literature indicating that digital tools and collaborative strategies can enhance engagement, reduce anxiety, and support achievement in mathematics, particularly when students experience supportive peer interactions and low-stakes, interactive learning opportunities (Ní Shé et al., 2023; Palancı & Turan, 2021; Rahma & Nurlaelah, 2024).

3.2 Canonical Correlation Between Student Dispositions and Mathematics Performance

3.2.1 Strength and Significance of the Multivariate Relationship

Canonical Correlation Analysis revealed a very strong and statistically significant multivariate relationship between student dispositions and mathematics performance. The first canonical correlation was 0.905, with a Wilks' Lambda value that was significant at $p < .001$, indicating that the combination of attention span, engagement, and learning anxiety is strongly associated with the combined indicators of perceived mathematics performance and final grades. The second canonical function was negligible and statistically insignificant, confirming that the primary relationship is captured in the first function. This strong canonical correlation demonstrates that students' dispositional characteristics in technology-enhanced collaborative settings are closely linked to how they perform and perceive their performance in mathematics. The result underscores the importance of affective and behavioral factors—such as reduced anxiety, sustained attention, and active engagement—in shaping mathematics outcomes when digital tools and group work are integrated. It supports the view that technology-enhanced collaborative environments do not merely deliver content but also cultivate dispositions that are conducive to learning and achievement (Drijvers & Sinclair, 2024; Quintero et al., 2022; Temurtaş, 2025).

3.2.2 Contributions of Individual Variables to the Canonical Variates

Among the student dispositions, learning anxiety had the strongest standardized canonical coefficient (−0.538), indicating that it contributed most to the disposition variate. Attention span (−0.274) and student engagement (−0.257) also contributed, though to a lesser extent. For the mathematics performance set, perceived mathematics performance had a dominant standardized coefficient (−1.001), while final grade contributed minimally (0.004). These coefficients indicate that confidence and comfort in collaborative, technology-supported environments play a critical role in influencing mathematics performance, more so than attention or engagement alone. Moreover, the overwhelming contribution of perceived mathematics performance, compared to the near-zero contribution of final grades, suggests that students' self-assessment of their understanding and progress is more closely tied to their dispositions than their actual grades. This pattern aligns with prior research showing that student perceptions of performance often reflect emotional and behavioral dispositions more strongly than objective achievement measures, particularly in supportive, interactive learning contexts (Ulum & Küçükdanacı, 2022; Zhu et al., 2024).

3.2.3 Canonical Loadings and Cross-Loadings

Canonical loadings further highlighted the influence of learning anxiety, which obtained the highest loading (−0.965) among dispositions, followed by student engagement (−0.931) and attention span (−0.884). For the performance set, perceived mathematics performance had a perfect canonical loading (−1.000), whereas final grade had a much lower loading (−0.165). Cross-loadings showed strong associations between dispositions and perceived performance, with learning anxiety (−0.873), student engagement (−0.842), and attention span (−0.800) all strongly correlated with the performance variate. Perceived mathematics performance had a cross-loading of −0.905, while final grade had a minimal cross-loading (0.149). These loadings and cross-loadings reinforce that learning anxiety is the most influential disposition in the multivariate relationship, and that perceived mathematics performance is the primary indicator of student achievement in this context. The weak association of final grades with the disposition variate emphasizes that how students feel about their mathematics learning is more strongly linked to their dispositions than their actual grades. This finding is consistent with literature suggesting that affective factors, such as anxiety and confidence, are closely related to students' self-perceptions of competence and success in mathematics, sometimes more so than to their measured achievement (Barroso et al., 2021; Demedts et al., 2022; Wardat et al., 2023).

3.2.4 Variance Explained by the Canonical Variates

Analysis of variance for the canonical variates showed that 86% of the variance in the disposition set was explained by its own variables, and 70.4% of this variance was shared with the mathematics performance set. For the performance set, 51.4% of the variance was explained by its own variables, and 42% was explained by the disposition set. The second canonical function accounted for negligible variance in both sets. These values indicate that student dispositions are strongly defined by attention span, engagement, and learning anxiety, and that a substantial portion of this dispositional variance is associated with mathematics performance. Likewise, a moderate-to-high proportion of performance variance is attributable to students' dispositions, suggesting that attitudes and behaviors during learning significantly influence mathematics outcomes in technology-enhanced collaborative settings. The minimal contribution of the second function confirms that the primary interpretable relationship lies in the first canonical function, emphasizing the central role of positive dispositions—especially

reduced anxiety and increased confidence—in supporting mathematics performance (Eidlin-Levy et al., 2023; Yang & Chen, 2024; Sofroniou et al., 2025).

4. Conclusion & Recommendations

The study found a strong relationship between student dispositions and mathematics performance in technology-enhanced collaborative learning environments. Students reported high levels of attention span, engagement, and learning anxiety, as well as positive perceived mathematics performance, while most achieved outstanding or very satisfactory mathematics grades. Canonical Correlation Analysis showed a strong multivariate relationship between the two variable sets, with learning anxiety emerging as the most influential disposition. Perceived mathematics performance was more closely associated with student dispositions than actual grades, indicating that students' feelings and behaviors during collaborative learning are strongly connected to how they assess their mathematics success.

Educators should integrate collaborative technology tools into mathematics instruction to enhance engagement and reduce anxiety. Learning activities should promote peer interaction and group work to strengthen student confidence and perceived performance, while supportive and non-judgmental environments should be established to address mathematics anxiety. Teachers should also use student reflections to monitor learning progress because perceived performance was more closely associated with student dispositions than actual grades. In addition, teacher-training programs should provide strategies for effective technology integration and for understanding student dispositions.

5. Compliance with ethical standards

This study adhered to ethical principles in educational research, including respect for participants, integrity, and confidentiality. Permission was obtained from the school administration prior to data collection. Participants were informed of the study's purpose, procedures, and the voluntary nature of their involvement through an informed consent process. Responses were treated with strict confidentiality and used solely for academic purposes; no personally identifiable information was collected, and participants retained the right to withdraw at any time without penalty. Ethical standards of honesty, fairness, and transparency were observed throughout, with no deception or coercion employed. The authors declare no conflicts of interest.

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