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RESEARCH ARTICLE

The Influence of Integrating Interdisciplinary Tasks on Mathematics Cognitive Development and Student Engagement

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ABSTRACT

This study investigates the influence of integrating interdisciplinary tasks on student engagement and cognitive development in learning Mathematics among Grade 10 students. Employing a descriptive-correlational research design, a structured self-administered questionnaire was utilized to gather student data, focusing on three main aspects: student engagement, the contribution of interdisciplinary tasks to cognitive development, and students' perceptions toward interdisciplinary task integration. Results indicate that integrating interdisciplinary tasks positively influences student engagement, with students reporting increased interest, enjoyment, participation, motivation, curiosity, and eagerness to explore mathematical concepts when integrated with other subjects. Furthermore, integrating interdisciplinary tasks significantly contributes to students' cognitive development within mathematical concepts, fostering improvements in critical thinking, problem-solving skills, understanding complex mathematical ideas, mathematical reasoning, creativity, and cognitive growth. Students perceive a relatively high level of interdisciplinary task integration within mathematical concepts, acknowledging the benefits of curriculum integration in enhancing their understanding and relevance of mathematics. Strong, positive, and significant relationships exist between student engagement, the extent of contribution to cognitive development, and the perceived level of integrating interdisciplinary tasks, emphasizing the importance of actively involving students in interdisciplinary tasks to promote engagement and relevance. These findings emphasize the potential of interdisciplinary approaches to reshape mathematical education, providing valuable insights for educators, policymakers, and stakeholders to enhance educational practices and empower students for success in an interconnected world. Based on these results, a proposed learning plan integrating interdisciplinary tasks in teaching mathematics is proposed, emphasizing collaborative learning experiences that promote deeper understanding and real-world relevance.

INTRODUCTION

The traditional compartmentalization of subjects is giving way to a more holistic and interconnected approach, ushering in a new era of pedagogical exploration. Among the exciting frontiers of this shift is the intersection of mathematical education and interdisciplinary integration. This emerging educational paradigm seeks to unravel the potential benefits that arise from intertwining mathematical concepts with other fields of knowledge. At the heart of this exploration lies a dual-

pronged inquiry: how does such integration of interdisciplinary tasks influence students' cognitive development, and how does it impact their levels of engagement and enthusiasm for learning?

As the boundaries between disciplines blur, researchers and educators are joining forces to investigate the profound implications of this approach on cognitive development. Cognitive theories suggest that the integration of mathematical concepts with other subjects could provide learners with a more comprehensive and interconnected understanding of complex ideas. Through the application of mathematical principles in contexts beyond traditional mathematics classrooms, students may develop an enhanced capacity for abstract reasoning, critical thinking, and problem-solving (Dolapcioglu & Doğanay, 2022). This cognitive enrichment, cultivated through interdisciplinary connections, holds the promise of better equipping students with skills that transcend the confines of individual subjects.

Furthermore, the impact of integrating interdisciplinary tasks on student engagement is a central focal point of this study. By bridging the gap between mathematical theories and real-world applications, educators aspire to instill a sense of relevance and excitement that can elevate students' interest in mathematics (Jaworski & Gellert, 2003). Research indicates that the incorporation of interdisciplinary elements can create a more stimulating and captivating learning environment, fostering intrinsic motivation and sustained engagement among students (Ammar et al., 2024). This approach not only cultivates a deeper appreciation for mathematical concepts but also paves the way for students to perceive the subject as a dynamic tool with diverse applications.

In the pursuit of unraveling the potential of interdisciplinary connections in mathematical education, this research delves into both theoretical underpinnings and practical implementations. This study aims to provide a comprehensive understanding of how the integration of interdisciplinary tasks can reshape the landscape of mathematical education. Through a multidimensional exploration of its impact on cognitive development and student engagement, educators, policymakers, and stakeholders can glean insights to enhance educational practices and empower students to thrive in an interconnected world.

Theoretical Framework

At the core of this study lies a robust theoretical framework that draws from cognitive development theories, educational psychology, and the integration of interdisciplinary task models. Constructivist learning theories, as advanced by Piaget (1970) and Vygotsky (1978), provide the foundation for understanding how students construct knowledge. These theories highlight the importance of active engagement with meaningful experiences, suggesting that integrating mathematical concepts into various disciplines can foster enhanced cognitive development. By connecting mathematical concepts to real-world applications within interdisciplinary contexts, learners are exposed to diverse perspectives and applications, facilitating abstract reasoning and cognitive flexibility (Valentine & Kopcha, 2016).

Complementing the cognitive perspective, educational psychology principles, particularly those outlined in Self-Determination Theory by (Ryan et al., 2021), shed light on the intricate relationship between engagement and motivation. This theory posits that students are more likely to be engaged when they perceive their learning experiences as autonomous, competent, and relevant to their interests. Interdisciplinary connections offer educators a platform to harness students' intrinsic motivation by presenting mathematical ideas in relatable and captivating contexts. (Juškevičienė et al., 2021).

Conceptual Framework

Student engagement is recognized as a cornerstone of effective learning (Bowman, 2022), and interdisciplinary task integration has emerged as a strategy to enhance this engagement by linking diverse subjects with mathematical content (Maass et al., 2019). This integration approach nurtures students' perception of mathematics as a practical tool with real-world applications, fostering deeper understanding (Dunsmore et al., 2011).

The extent of interdisciplinary tasks emerges as a crucial factor in augmenting these cognitive benefits. Aligning with this understanding, a proposed interdisciplinary approach in teaching Math seeks to leverage the potential of an integrated interdisciplinary task. Building on this approach, the program emphasizes not only cross-disciplinary connections but also metacognition and the transfer of learning. Students are encouraged to reflect on their cognitive processes across subjects, leading to improved cognitive strategies (Michalsky & Cohen, 2021). Furthermore, the program provides avenues for the application of mathematical principles across varied contexts, enhancing comprehension and retention (Jungck et al., 2020).

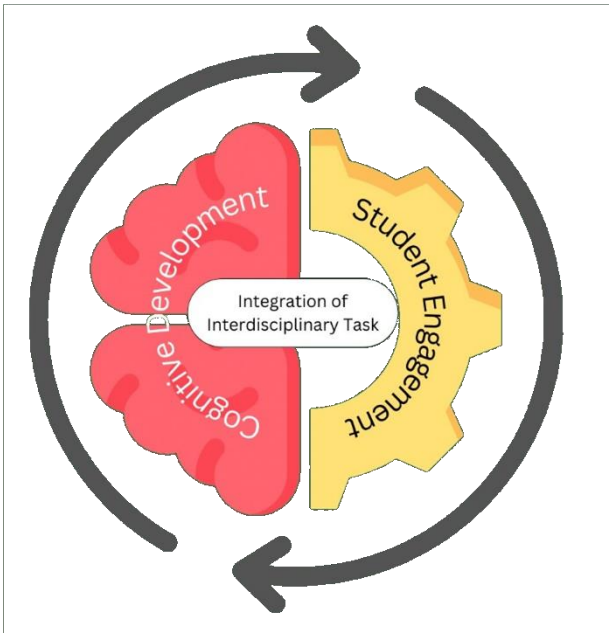

Figure 1. Schematic Diagram of the Study

METHODOLOGY

The study used a descriptive-correlational research design to explore how the integration of interdisciplinary tasks affects Grade 10 students' cognitive development and engagement. It aimed to understand the relationship between students' involvement, thoughts, and experiences with interdisciplinary tasks in math. The research treated interdisciplinary tasks as the independent variable, while cognitive development and student engagement were seen as dependent variables. Surveys with structured questions were used to gather data on student engagement, employing Likert scales for quantitative analysis.

Conducted across all secondary schools in Carmen District, Agusan del Norte Division, the study focused on four main institutions. Participants included Grade 10 students from the four schools, with a total of 209 students chosen using specific sampling techniques. Random selection ensured fairness and avoided bias. A self-administered questionnaire was the primary research instrument, pre-tested for clarity and reliability. Ethical guidelines were followed throughout the data collection process. Statistical treatments like mean calculation and correlation analysis, specifically Spearman's rho test, were employed to analyze the data, revealing insights into the relationships between variables and providing a basis for meaningful conclusions.

RESULTS AND DISCUSSIONS

Table 1 exhibits the degree of integrating interdisciplinary tasks into mathematical concepts. As viewed in the table, the high average score (4.22) indicating that students highly perceive the integration of mathematical concepts with other subjects as prevalent in their academic environment is consistent with research findings. Increasing trend of incorporating interdisciplinary approaches

into education to promote deeper learning and real-world relevance (Hernández et al., 2023). On the other hand, the lowest mean score is still relatively high (3.71), indicating that interdisciplinary connections might not be as frequent as perceived to align with research while integration efforts are present, they may vary in frequency and effectiveness across different educational contexts (Huang et al., 2022). Despite being the lowest mean score, it still reflects a positive perception of interdisciplinary integration within the educational setting. The overall mean score of 3.97 indicates the average rating assigned by students regarding the perceived level of integrating interdisciplinary tasks in mathematical concepts.

Table 1. ***Perceived Level of Integrating Interdisciplinary Tasks in Mathematical Concepts of the Students***

Indicator	Mean	Remark	Interpretation
1. The integration of mathematical concepts with other subjects is a common practice in my educational experience.	4.22	High	Have a positive inclination toward the statement.
2. Interdisciplinary connections between math and other subjects are often encountered in my curriculum.	3.83	High	Have a positive inclination toward the statement.
3. Math is frequently integrated with other subjects in my classroom.	3.71	High	Have a positive inclination toward the statement.
4. The integration of interdisciplinary tasks enhances my understanding of mathematical concepts.	3.92	High	Have a positive inclination toward the statement.
5. Connections between math and other subjects in my lessons are easily identifiable.	4.52	High	Have a positive inclination toward the statement.
6. My teachers actively promote the integration of math with other areas of study.	3.85	High	Have a positive inclination toward the statement.
7. Conducting interdisciplinary tasks encouraged me to explore mathematical concepts within the context of other subjects.	3.90	High	Have a positive inclination toward the statement.
8. The integration of interdisciplinary activities makes math more engaging and relevant.	3.93	High	Have a positive inclination toward the statement.
9. My curriculum is designed to help me see the practical applications of mathematical concepts.	3.93	High	Have a positive inclination toward the statement.
10. Interdisciplinary task integration helps me connect the different areas of knowledge.	4.07	High	Have a positive inclination toward the statement.
11. Integrating math with other subjects enhances my overall learning experience.	3.97	High	Have a positive inclination toward the statement.
12. My educational institution values the integration of mathematical concepts with other subjects.	3.78	High	Have a positive inclination toward the statement.
13. The benefits of integrating interdisciplinary tasks in improving my problem-solving skills.	3.97	High	Have a positive inclination toward the statement.
14. Interdisciplinary tasks foster a deeper understanding complex mathematical ideas.	3.87	High	Have a positive inclination toward the statement.
15. Interdisciplinary tasks are viewed as an important aspect of my education.	4.01	High	Have a positive inclination toward the statement.
Overall	**3.97**	**High**	Have a positive inclination toward the statement.

Legend: 1.00 – 1.49 Very Low; 1.50 – 2.49 Low; 2.50 – 3.49 Moderate; 3.50 – 4.49 High; 4.50 – 5.00 Very High

This overall mean indicates that students perceive a relatively high level of interdisciplinary task integration in mathematical concepts and incorporate mathematics effectively across various subjects or areas of study. In other words, mathematical concepts are effectively integrated into their curriculum, as an important aspect of education, and indicate a positive perception of the interdisciplinary approach to learning. These perceptions can have implications for teaching practices, curriculum design, educational policies, and interconnected learning experiences for

students. Despite the positive perception, there may still be room for improvement in integrating interdisciplinary efforts. This result may be an eye-opener for educators to refine existing integration strategies, develop new interdisciplinary approaches, or address any gaps in curriculum alignment to further enhance students' understanding and appreciation of mathematical concepts.

Table 2 shows the level of student engagement in mathematical concepts facilitated by the integration of interdisciplinary tasks. As can be seen in the table, students highly believed that interdisciplinary task helps them connect different pieces of information and knowledge, with a mean of 4.24. The implication of this result may be linked to the study of Lee et al (2024) that linking mathematics to other subjects facilitates deeper understanding and promotes conceptual mastery. Practical applications and real-world connections increase students' confidence and motivation in learning mathematics (Cabuquin & Abocejo, 2023).

Table 2. ***Level of Student Engagement in Mathematical Concepts Through the Integration of Interdisciplinary Task***

Indicators	**Mean**	**Remark**	**Interpretation**
1. I find that the integration of interdisciplinary tasks in mathematics makes me more interested in learning math concepts.	4.11	High	Have a positive inclination toward the statement.
2. I find math lessons more enjoyable when they are connected to other subjects like science or art.	3.83	High	Have a positive inclination toward the statement.
3. I actively participate in class discussions and activities related to integrated math concepts.	3.76	High	Have a positive inclination toward the statement.
4. I find that interdisciplinary task helps me see the real-world applications of math.	3.90	High	Have a positive inclination toward the statement.
5. I feel motivated to learn math when it is taught in conjunction with other subjects.	3.75	High	Have a positive inclination toward the statement.
6. I am curious and eager to explore math concepts when they are part of interdisciplinary projects.	3.79	High	Have a positive inclination toward the statement.
7. I find integrating math with other subjects helps me understand complex mathematical ideas better.	4.05	High	Have a positive inclination toward the statement.
8. I am more likely to complete math assignments when it is involved with interdisciplinary tasks.	3.87	High	Have a positive inclination toward the statement.
9. I feel more confident in my math skills when they are applied in interdisciplinary activities.	3.91	High	Have a positive inclination toward the statement.
10. I look forward to math lessons when they involve collaborating with students from different subjects.	3.67	High	Have a positive inclination toward the statement.
11. I find math more relevant to my life when it is integrated with other areas of study.	3.83	High	Have a positive inclination toward the statement.
12. I find that interdisciplinary task makes me think critically and creatively about math.	3.84	High	Have a positive inclination toward the statement.
13. I am willing to spend extra time on math-related projects that are integrated with other subjects.	3.75	High	Have a positive inclination toward the statement.
14. I believe that interdisciplinary tasks help me connect different pieces of information and knowledge.	4.24	High	Have a positive inclination toward the statement.
15. I believe that interdisciplinary task enhances my overall learning experience in math.	4.12	High	Have a positive inclination toward the statement.
Overall	**3.90**	**High**	Have a positive inclination toward the statement.

Legend: 1.00 – 1.49 Very Low; 1.50 – 2.49 Low; 2.50 – 3.49 Moderate; 3.50 – 4.49 High; 4.50 – 5.00 Very High

On the other hand, the lowest mean score, though still relatively high (3.67), suggests a slightly lower level of agreement compared to the highest mean scores. This statement indicates that respondents generally look forward to math lessons when they collaborate with students from different subjects. Despite being the lowest mean score, it still reflects a positive perception of interdisciplinary collaboration within the educational setting. Research has shown that connecting mathematical concepts to real-world contexts and other subjects can enhance students' engagement and motivation (Hwang & Ham, 2021). Hands-on, collaborative learning experiences promote student engagement and willingness to participate in classroom activities (Bae et al., 2020). Integrating interdisciplinary tasks enhances students' overall learning experience in mathematics by providing diverse learning opportunities and promoting meaningful engagement.

The level of student engagement in mathematical concepts through the integration of interdisciplinary tasks has an overall mean of 3.90 which indicates a positive level of engagement. The findings were supported by a study by Roth (2020) who found that integrating mathematics with other subjects positively impacts student engagement and learning experiences, indicating the effectiveness of interdisciplinary approaches in math education. Similarly, Nakakoji & Wilson (2020) examined the impact of interdisciplinary integration on mathematical problem-solving skills, and they found that integrating math with other subjects increased student participation in problem-solving activities and enhanced their overall engagement in the learning process.

Table 3 illustrates the degree to which integrating interdisciplinary tasks contributes to mathematics cognitive development**.**

Table 3.***Contribution of the Interdisciplinary Task to Mathematical Cognitive Development***

Indicator	**Mean**	**Remark**	**Interpretation**
1. Interdisciplinary tasks enhance my ability to think critically about mathematical problems.	4.07	High	Have a positive inclination toward the statement.
2. Integrated math lessons help me connect mathematical concepts with concepts from other subjects.	3.94	High	Have a positive inclination toward the statement.
3. Feeling more confident in my problem-solving skills occurs when math is integrated with other subjects,	3.72	High	Have a positive inclination toward the statement.
4. Integrating math with other subjects deepens my understanding of mathematical concepts.	3.89	High	Have a positive inclination toward the statement.
5. Integrating interdisciplinary tasks encourages me to apply mathematical principles in real-world contexts.	3.68	High	Have a positive inclination toward the statement.
6. Integrated math projects require me to analyze and synthesize information from multiple sources.	3.94	High	Have a positive inclination toward the statement.
7. Interdisciplinary task improves my mathematical reasoning skills.	3.85	High	Have a positive inclination toward the statement.
8. Integrated math lessons stimulate my curiosity and interest in exploring mathematical concepts.	4.11	High	Have a positive inclination toward the statement.
9. Math concepts are remembered and retained better when they are integrated with other subjects.	3.79	High	Have a positive inclination toward the statement.
10. Integrating interdisciplinary tasks challenges me to approach math problems from different angles.	3.97	High	Have a positive inclination toward the statement.
11. Integrated math projects promote creative thinking and problem-solving.	3.96	High	Have a positive inclination toward the statement.
12. The cognitive challenge of integrating mathematical concepts into interdisciplinary activities is enjoyable.	3.83	High	Have a positive inclination toward the statement.
13. The integration of interdisciplinary tasks enhances My overall cognitive development.	3.83	High	Have a positive inclination toward the statement.

14. Integrated math lessons encourage me to make connections between different areas of knowledge.	4.05	High	Have a positive inclination toward the statement.
15. The integration of interdisciplinary tasks contributes significantly to my cognitive growth within mathematical concepts.	4.00	High	Have a positive inclination toward the statement.
Overall	**3.91**	**High**	Have a positive inclination toward the statement.

Legend: 1.00 – 1.49 Very Low; 1.50 – 2.49 Low; 2.50 – 3.49 Moderate; 3.50 – 4.49 High; 4.50 – 5.00 Very High

Based on the results presented, the respondents generally have a positive inclination toward the integration of interdisciplinary tasks with mathematics. The highest mean score is 4.11, indicating that respondents agree that integrated math lessons pique their curiosity and interest in exploring mathematical concepts. This finding implies that integrating math with other subjects successfully engages students and makes mathematics more captivating and intriguing for them. It shows that when students see the relevance of mathematics in various contexts, they are more motivated to explore and understand it deeply. It enhances their ability to think critically about mathematical problems, stimulates curiosity and interest, and believes that curriculum integration contributes significantly to their cognitive growth within mathematical concepts (Maass, et al., 2019).

On the other hand, the statement "integrating interdisciplinary tasks encourages me to apply mathematical principles in real-world contexts" received the lowest mean score of 3.68 among the items listed. This finding implies that while respondents generally agree with the statement, there may be some reservations or variability in the extent to which they feel encouraged to apply mathematical principles in real-world contexts through interdisciplinary tasks. It could indicate that while integration fosters some real-world applications, there might be room for improvement in making these connections more explicit or relevant for students.

The extent to which integration of interdisciplinary tasks contributes to the cognitive development of students in mathematical concepts has an overall mean of 3.91. This implies that the integration of interdisciplinary tasks encourages the development of higher order thinking skills such as analysis, synthesis, and evaluation. Participants' responses show that integrating interdisciplinary tasks contributed to their overall cognitive development, indicating a positive impact on their intellectual growth beyond mathematical concepts alone. This result is supported by Ivanitskaya et al. (2002) stated in Nowell, et al (2020) that interdisciplinary learning can make knowledge that is "more holistic than knowledge built in discipline-specific studies". When students engage in interdisciplinary aspects that require them to analyze data, design experiments, or make connections between different concepts, they are exercising cognitive skills that go beyond rote memorization and procedural understanding.

Table 4 shows and presents the significant relationship between the level of student engagement, the extent of contribution, and the perceived level of integrating interdisciplinary tasks within the mathematical concepts of the students.

As observed, the level of student engagement was found to be strongly, positively, and significantly related to both the extent of contribution to cognitive development and perceived level of integrating interdisciplinary tasks, with $\rho_1 = 0.836, p = 0.000$, and $\rho_2 .706, p = 0.000$, respectively. This indicates that as the level of engagement of the students in mathematical concepts through the implementation of integrating interdisciplinary tasks increases, both the extent of integrating interdisciplinary tasks' contribution to cognitive development and the perceived level of integrating interdisciplinary tasks strongly increases. Additionally, the extent of contribution to cognitive development and perceived level of integrating interdisciplinary tasks were found to have a strong, positive, and significant relationship, with $\rho_3 = 0.784, p = 0.000$. Hence, as the perceived level of integrating interdisciplinary tasks increases, the integrating interdisciplinary tasks contribution to cognitive development strongly increases.

Table 4. ***A Significant Relationship between the Level of Student Engagement, Extent of Contribution, and Perceived Level of Integrating Interdisciplinary Tasks within Mathematical Concepts of the Students***

Variable 1	Variable 2	Correlation Coefficient[a]	p-value	Relationship	Significance
Level of student engagement	Extent of the contribution of Interdisciplinary Task (IT) to cognitive development	0.836	<0.001***	Strong and positive	*Significant*
	Perceived level of IT	0.706	<0.001***	Strong and positive	*Significant*
Extent of the contribution of IT to cognitive development	Perceived level of IT	0.784	<0.001***	Strong and positive	*Significant*

*Legend: [a] tested using Spearman's rho correlation test; -1.0 to -0.5 or 1.0 to 0.5 strong relationship; -0.5 to -0.3 or 0.3 to 0.5 moderate relationship; -0.3 to -0.1 or 0.1 to 0.3 weak relationship; -0.1 to 0.1 none or very weak relationship; *** significant at $\alpha = 0.01$;** significant at $\alpha = 0.05$*

The strong, positive, and significant relationship (ρ = 0.836, p = 0.000) between the level of student engagement and the extent of contribution to cognitive development highlights the importance of actively involving students in interdisciplinary tasks within mathematics education. This finding suggests that as students become more engaged in mathematical concepts through curriculum integration, their cognitive development is significantly enhanced. This aligns with research indicating that engaged students are more likely to demonstrate deeper understanding and mastery of concepts (Zitha et al., 2023).

Similarly, the strong, positive, and significant relationship (ρ = 0.706, p = 0.000) between student engagement and the perceived level of integrating interdisciplinary tasks emphasizes the crucial role of curriculum design and implementation in fostering student engagement. Higher levels of student engagement are associated with a greater perception of interdisciplinary tasks within mathematical concepts. This underscores the importance of creating learning environments that promote interdisciplinary connections and relevance to students' lives, which can enhance their motivation and interest in mathematics (Maass et al., 2019).

The strong, positive, and significant relationship (ρ = 0.784, p = 0.000) between the extent of contribution to cognitive development and the perceived level of interdisciplinary tasks suggests that students' perceptions of interdisciplinary tasks align closely with its actual impact on cognitive development. When students perceive a higher level of interdisciplinary tasks within mathematical concepts, there is a greater recognition of its contribution to cognitive development. This underscores the importance of aligning students' perceptions with instructional practices to maximize the effectiveness of interdisciplinary task strategies (Borda et al., 2020). These results underscore the importance of creating learning environments that promote active engagement, interdisciplinary connections, and meaningful integration of curriculum to enhance students' learning experiences and cognitive growth in mathematics education.

CONCLUSION

Based on the findings of the study, the following conclusions are derived: students perceive a relatively high level of interdisciplinary task integration within mathematical concepts. Although variations may exist across different contexts, students generally recognize the benefits of these tasks in enhancing their understanding and the relevance of mathematics. This widespread recognition suggests that interdisciplinary tasks play a significant role in making mathematical concepts more relatable and comprehensible to students.

Integrating interdisciplinary tasks in mathematics positively impacts student engagement. When mathematical concepts are integrated with other subjects, students express increased interest, enjoyment, active participation, motivation, curiosity, and eagerness to explore these concepts. This heightened engagement indicates that interdisciplinary approaches create a dynamic and stimulating learning environment, fostering a deeper connection with mathematical concepts and encouraging a more enthusiastic approach to learning.

Students reported improvements in critical thinking, problem-solving skills, understanding complex mathematical ideas, mathematical reasoning, creativity, and cognitive growth. These findings highlight the effectiveness of interdisciplinary approaches in promoting higher order thinking skills and enhancing students' conceptual understanding of mathematics. The reported improvements suggest that interdisciplinary tasks not only make mathematics more engaging but also more intellectually rewarding.

The degree of contribution to cognitive development, student engagement, and perceived level of curriculum integration were found to have a strong, positive, and significant relationship. Higher levels of student engagement are associated with greater contributions to cognitive development and a more positive perception of the integration of interdisciplinary tasks. This relationship underscores the importance of integrating interdisciplinary tasks into the curriculum to maximize both student engagement and cognitive growth.

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