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Designing and implementing teachers' professional development program on crafting brain-based lessons

Vanjoreeh A. Madale[1], Jamaliah A. Casidar[2], Manuel B. Barquilla[1], Monera A. Salic-Hairulla[1], John Jr G. Adil[3], Arlyn R. Alcopra[3]
[1]Department of Science and Mathematics Education, College of Education, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines
[2]Adiong Memorial State College, Ditsaan-Ramain, Philippines
[3]Department of Professional Education, College of Education, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines

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ABSTRACT

The increasing emphasis on brain-based learning (BBL) underscores its potential to enhance educational practices by integrating the biological foundations of learning. This study, conducted at Mat-I National High School, sought to address the gap between theoretical understanding and practical application of BBL among science and mathematics educators. Using a descriptive research design, the study aimed to develop and implement a comprehensive training designed to elevate teachers' proficiency in BBL strategies, ultimately improving their instructional effectiveness in science and mathematics education. A pre-training needs assessment identified a superficial familiarity with BBL among teachers, underscoring the need for more targeted professional development. The training program incorporated lectures, workshops, interactive exercises, and the creation of lesson plans tailored to BBL principles. Post-training assessments demonstrated a marked improvement in participants' understanding and application of BBL, advancing from basic to proficient levels. These findings suggest that the program successfully enhanced teaching practices. The study concludes by recommending continuous professional development, the development of BBL-aligned teaching tools, and the adoption of varied training methodologies to sustain and further improve educational outcomes in mathematics and science education.

Corresponding Author:

Vanjoreeh A. Madale
Department of Science and Mathematics Education, College of Education
Mindanao State University-Iligan Institute of Technology
Iligan City, Philippines
Email: vanjoreeh.madale@g.msuiit.edu.ph

1. INTRODUCTION

Teacher professional development (TPD) programs are crucial in enhancing teaching practices and improving educational outcomes, but their implementation often lacks coherence and sustainability. Research shows that effective TPD should be job-embedded, collaborative, and ongoing to foster teacher engagement and improve instructional practices [1]. While long-term, collaborative, school-based programs have been found most effective when connected to teachers' daily practices and prior knowledge [2], many existing initiatives fail to fully integrate these key elements. Competency-based training programs focusing on critical thinking, creativity, communication, and collaboration have significantly improved teachers' classroom effectiveness [3], yet the lack of continuity and contextual adaptation limits their broader impact.

School-based TPD, tailored to meet the specific needs of teachers, students, and schools, presents a more personalized approach than traditional one-size-fits-all programs [4]. Additionally, the establishment of teachers resource centers offers a valuable opportunity for interactive coaching and mentoring, which is vital for sustained professional growth [5]. Despite these promising approaches, there is still a gap in the dynamic integration of these features into a cohesive professional development framework.

Brain-based learning (BBL) has gained significant attention in the field of education due to its focus on understanding learning as a biological process. Research has shown that implementing BBL approaches in teaching can have positive effects on students' motivation, attitudes, and academic achievement [6]–[8]. By incorporating neuroscience research into educational practices, teachers can create more effective learning environments that cater to the natural laws of the brain and align with constructivist education theories [9]. Studies have emphasized the importance of building a scientific groundwork for BBL, advocating for a skeptical approach towards brain-based claims and promoting systematic collaboration between researchers, teachers, and students [10]. It is crucial for educators to develop scientific literacy skills to navigate the field of brain-based education successfully [11]. Additionally, training for neuroeducators should include rigorous evaluation methods to connect education with practice and avoid exaggerated claims commonly found in brain-based education advertisements [12]. BBL has been found to enhance students' cognitive structures, facilitate learning, and improve academic outcomes across various subjects, including mathematics, science, and language [13]–[15]. Implementing brain-based instructional strategies based on the brain's natural learning systems can benefit all students, including those in inclusive classrooms in higher education [16]. Furthermore, BBL approaches have been shown to improve students' conceptual understanding, creativity, communication abilities, and self-efficacy [17].

The Philippines' low ranking in the program for international student assessment (PISA) can be attributed to various factors based on the available literature. One significant reason is the poor performance of Filipino students in reading comprehension, mathematics, and science, as evidenced by their rankings near the bottom among participating countries [18], [19]. This indicates challenges in students' proficiency in these core subjects, which are crucial for academic success and overall educational development. Additionally, the prevalence of fixed mindsets among Filipino students has been highlighted as a contributing factor to the country's low PISA scores. Countries with low PISA rankings, including the Philippines, often exhibit a high proportion of students categorized into a fixed mindset, which can impact their learning outcomes and academic achievement [20]. Addressing mindset issues and promoting growth mindsets among students could potentially lead to improvements in learning attitudes and performance.

Furthermore, challenges in building students' science literacy and struggles in developing students' proficiency in science have been identified as areas of concern in the Philippines' educational system [21]. Science literacy is essential for students to engage effectively with scientific concepts and apply critical thinking skills, which are evaluated in assessments like PISA. Addressing gaps in science education and promoting creativity and novelty in curriculum design could potentially lead to improvements in students' performance in science-related subjects. In the Philippines' educational system, building students' science literacy and developing their proficiency in science present significant challenges. One key area of concern is the integration of BBL strategies, which emphasize the importance of aligning teaching methods with how the brain naturally learns. These strategies often include active learning, multisensory engagement, and fostering a positive emotional environment. However, the implementation of such methods is hindered by several factors, including a lack of resources, insufficient teacher training, and overcrowded classrooms. In this study, the researchers sought to bridge the gap between theory and practice offering educators a comprehensive training design that enriched their understanding of BBL and its relevance to science education. This enabled educators to effectively improve the teaching and learning process using the principles and concepts of BBL. Specifically, this research study aimed to:

i) What is the current level of teachers' knowledge and understanding regarding BBL?
ii) How does the developed professional program affect teachers' ability to apply BBL principles in their classroom practices before and after its implementation?

2. METHOD

This study employed a mixed-method descriptive research design to comprehensively evaluate the effectiveness of a BBL training program for educators. The research aimed to address specific gaps in teachers' instructional practices by first identifying these gaps through pre-assessment tools. The training program was then designed to directly target these areas, incorporating BBL strategies tailored to improve teaching methods. To measure the program's effectiveness, both qualitative and quantitative data were collected, including teacher reflections, classroom observations, and performance metrics. This approach ensures consistency between the research problem, which focuses on improving instructional practices through BBL, and the subsequent results, which highlight changes in teacher performance post-training.

2.1. Sampling criteria and research respondents

The research involved a purposive sampling method, selecting participants based on their relevance to the study's objectives. The respondents were seven teachers from Mat-I National High School, comprising two science teachers and five mathematics teachers. This sample was chosen because they were directly involved in teaching subjects where BBL techniques could significantly improve student engagement and retention. The participants were invited to join the study after expressing interest in enhancing their teaching methodologies and were willing to participate in all stages of the training program.

2.2. Data gathering procedure

The researchers embarked on a comprehensive series of steps to evaluate the effectiveness of the BBL training program. The key achievement indicators were: i) Conducting a needs assessment survey to identify participants' baseline knowledge, skills, and areas for improvement regarding BBL. Success was measured by the identification of specific gaps in knowledge and practice; ii) Designing a targeted training program based on the assessment results, with success measured by the alignment between identified gaps and the training content; iii) Validating the program through expert reviews, face validation, and a dry run. The effectiveness of this phase was determined by expert approval and any necessary revisions to the program; iv) Selecting Mat-I National High School as the research site and successfully integrating the program into the school's learning action cell (LAC) sessions. Achievement here was indicated by the seamless adaptation of the training into the existing LAC framework and the engagement of participants; v) Administering a pretest to establish participants' baseline understanding of BBL, with success measured by capturing the initial knowledge level of all participants; vi) Delivering engaging training sessions, including interactive activities such as games and collaborative lesson planning. The quality of participant engagement and interaction was a key indicator of success at this stage, evaluated through direct observation; vii) Participants were tasked with creating lesson plans integrating BBL strategies, and success was gauged by their ability to accurately apply BBL principles, as evaluated by the researchers; and viii) Concluding the program with a posttest to measure the participants' increase in knowledge and awareness of BBL. Success was indicated by a significant improvement in posttest scores compared to the pretest, demonstrating enhanced understanding of BBL concepts and strategies.

2.3. Criteria for selecting references

The references for the study were selected based on their relevance to BBL theories and practices, focusing on educational research that has established the benefits of BBL in improving teaching efficacy in science and mathematics. The citations from this study are only from reputable international journals that are Scopus indexed, peer-reviewed, and the like to ensure the validity and reliability of the study.

3. RESULTS AND DISCUSSION

3.1. The training design

The needs assessment carried out at Mat-I National High School identified crucial areas that needed to be addressed during training sessions. This evaluation helped to tailor the training curriculum to the specific needs and challenges that educator face in their professional environments. By identifying these key areas, the assessment ensured that the training was both relevant and impactful, enhancing educators' ability to improve science education by incorporating two fundamental psychological approaches to learning: "brain-based learning" and "classical and operant conditioning".

Table 1 presents an evaluation of respondents' familiarity, application, perceived effectiveness, and challenges associated with various learning concepts and techniques. The data is summarized using mean scores and corresponding verbal interpretations. Firstly, the category "familiarity with learning concepts" has a mean score of 2.34, which falls under the verbal interpretation of "beginner". This aligns with findings that emphasize the necessity for educators to enhance their understanding of foundational learning theories to improve educational outcomes [22]. In the category "application of learning theories," the mean score is 3.01, which is interpreted as "competent". This suggests that while respondents may only have a beginner's familiarity with the concepts, they are somewhat adept at applying these theories in practical scenarios. For example, research highlights that while educators may grasp theoretical concepts, translating these into effective teaching practices remains a challenge [23]. The "perceived effectiveness of learning techniques" category has a mean score of 2.15, which is also interpreted as "beginner". This skepticism is echoed in literature that discusses the barriers to effective learning implementations, particularly in contexts where educators feel inadequately prepared to utilize these techniques [24], [25]. Regarding "challenges and further learning," the mean score is 2.42, categorized as "beginner". This indicates that respondents face significant challenges in implementing these learning techniques and feel a need for further education and understanding in these areas. This aligns with findings that indicate a prevalent need for professional development and training among educators to effectively navigate the

complexities of modern educational environments [26]. The overall "grand mean" across all categories is 2.48, which maintains the "beginner" interpretation. This composite score suggests that, on average, respondents have a beginner level of familiarity, application, perceived effectiveness, and face notable challenges with learning concepts and techniques, highlighting an overall need for further training and development in these areas. This conclusion is supported by studies that advocate for comprehensive training programs to equip educators with the necessary skills to foster effective learning environments [27].

Table 2 presents the pre-training assessment results. This indicate that respondents generally rated themselves highly in various areas related to BBL. They felt most confident in applying BBL strategies (mean: 4.51) and differentiated instruction for diverse learners (mean: 4.36), both of which received an "excellent" verbal interpretation. Additionally, respondents demonstrated strong abilities in managing student anxiety and fear during stressful situations (mean: 4.25), also rated as "excellent". In promoting positive behavior and classroom management, the mean score was slightly lower at 4.11, interpreted as "very good". However, when it came to enhancing learning through brain-based teaching by integrating neuroscience principles into lesson planning, respondents felt less proficient, with a score of 3.49, though still within the "very good" range. Overall, the grand mean of 4.144 reflects a "very good" level of competence across all areas, suggesting that while respondents exhibit strong baseline skills, particularly in direct application of BBL strategies and differentiated instruction, there is room for growth in integrating neuroscience into their teaching practices. Research indicates that while many teachers are familiar with differentiated instruction, their understanding and implementation of these strategies can be superficial. For instance, a study revealed that only 34 out of 95 teachers could accurately describe the characteristics of differentiated instruction, highlighting a gap in knowledge and application [28]. This finding underscores the necessity for targeted professional development that not only enhances teachers' skills in differentiated instruction but also deepens their understanding of its theoretical underpinnings and practical applications [29]. Moreover, the integration of neuroscience into educational practices is an emerging area that requires attention. Educational neuroscience offers insights into how cognitive processes affect learning; however, many educators lack the necessary training to effectively apply these insights in the classroom [30].

Table 1. Respondents' needs assessment

Statement	Mean (x)	Verbal interpretation
Familiarity with learning concepts	2.34	Beginner
Application of learning theories	3.01	Competent
Perceived effectiveness of learning techniques	2.15	Beginner
Challenges and further learning	2.42	Beginner
Grand mean	2.48	Beginner

Table 2. Respondents' pre-training assessment

Statement	Mean (x)	Verbal interpretation
Managing student anxiety and fear: strategies for supporting students during stressful situations	4.25	Excellent
Promoting positive behavior and classroom management: techniques for encouraging cooperation and minimizing disruption	4.11	Very good
Enhancing learning through brain-based teaching: integrating neuroscience principles into lesson planning and instructional strategies	3.49	Very good
Applying BBL in teaching	4.51	Excellent
Differentiated instruction for diverse learners	4.36	Excellent
Grand mean	4.144	Very good

3.2. Implementation

The data presented in Figure 1 reflects the significant positive impact of the training program on participants' knowledge and skills across various teaching strategies. Initially, participants rated their ability to manage student anxiety and fear with a mean score of 2.77, which improved to 4.25 after the training. Similarly, their proficiency in promoting positive behavior and classroom management increased from 3.12 to 4.11. The understanding and application of brain-based teaching principles saw a notable rise from 2.23 to 3.49. Applying BBL strategies showed the most substantial improvement, with scores jumping from 2.62 to 4.51. Additionally, competence in differentiated instruction for diverse learners improved from 3.32 to 4.36. Overall, the grand mean scores illustrate a significant enhancement, rising from 2.812 before the training to 4.144 afterward. This data indicates that the training program was highly effective in enhancing participants' capabilities in these critical educational areas. The systematic review of differentiated instruction training supports this conclusion, demonstrating that such training not only improves teachers' instructional practices but also positively impacts student learning outcomes [31], [32]. The findings underscore the necessity of

ongoing professional development in differentiated instruction and brain-based teaching strategies to equip educators with the skills needed to address diverse learning needs effectively [33], [34].

Table 3 illustrates the impact of a training program on respondents' evaluations, comparing their pre- and post-training assessments. Before the training, the average score (mean) given by respondents was 2.81, with a standard deviation of 0.47, indicating a moderate spread in the responses. After the training, the average score significantly increased to 4.14, with a reduced standard deviation of 0.39, suggesting that respondents' evaluations became more uniformly positive. The Wilcoxon signed rank test, a statistical method used to compare two related samples, was applied to determine if the observed difference between pre- and post-training assessments was statistically significant. The sum of ranks for positive differences was 15, and the positive rank value was 3.00, indicating that all respondents rated the post-assessment higher than the pre-assessment. There were no negative ranks, meaning no respondent rated the post-assessment lower than the pre-assessment. The test yielded a test statistic (Z) of 2.023. The associated P-value was 0.043, which is below the commonly accepted threshold of 0.05 for statistical significance. This means that there is less than a 5% probability that the observed improvement in scores occurred by chance. Therefore, we can conclude that the training program had a significant positive impact on the respondents' evaluations. In summary, the table shows that the training program led to a statistically significant improvement in the respondents' assessments, as evidenced by the higher mean score and more consistent positive evaluations post-training. The Wilcoxon signed rank test results confirm that this improvement is unlikely to be due to random variation, highlighting the effectiveness of the training program. The overall findings from the training program underscore the necessity of ongoing professional development in BBL strategies. Educational interventions that incorporate peer education and interactive methodologies can lead to improved knowledge and skill application among participants [35]. This is further supported by evidence that continuous training and assessment are vital for maintaining and enhancing educational competencies over time [36].

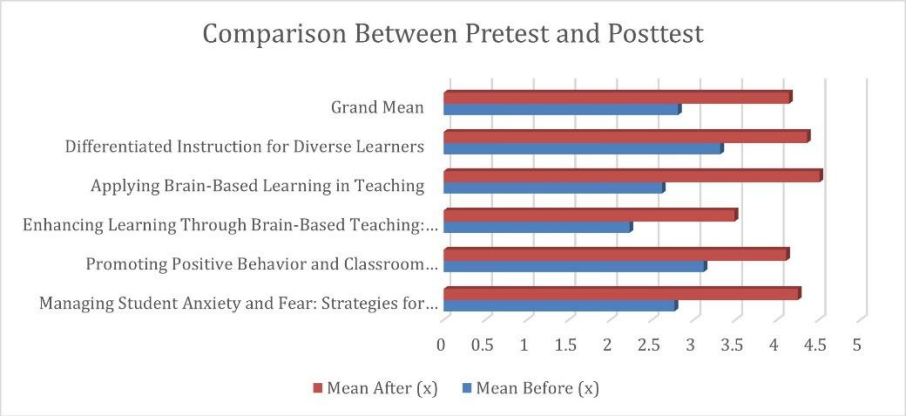

Figure 1. Comparison between pretest and posttest

Table 3. Significant difference between the pre and post training assessment of the respondents using Wilcoxon signed rank test

Assessment	Mean	SD	Sum of rank	Positive rank	Negative rank	Test statistic (Z)	P-value	Qualitative interpretation
Pre-assessment	2.81	0.47	15	3.00	0.00	2.023	0.043	Significant
Post assessment	4.14	0.39	0					

3.3. Lesson plans crafted

In the Figures 2 and 3, Mr. Jimboy M. Buray conducted a grade 9 mathematics lesson at Mat-I (Naawan) National High School, focusing on the quadratic function. The objective was for 80% of the students to be able to determine the equation of a quadratic function, analyze the effects of changing values in the equation on its graph, and draw these graphs. The lesson began with a prayer and attendance check, followed by a review of the previous lesson through a supplemental video on quadratic equations. To establish the purpose of the lesson, a motive question was posed about whether it is possible to draw the graph of quadratic functions without solving them. The lesson then presented examples by having students complete a table of values for *aa*, *hh*, and *kk*, and draw corresponding graphs. This activity helped students generalize the effects of changes in the quadratic function's equation on its graph. The lesson proceeded with discussing new concepts and practicing

skills, where students analyzed the graphs of quadratic functions, compared graphs with vertices above and below the origin, and learned to graph by sliding horizontally and vertically. Students found the values of *aa*, *hh*, *kk*, the vertex, and the line of symmetry for given quadratic functions, and then drew these graphs on the same coordinate plane. For developing mastery, students drew graphs of specified quadratic functions on the same coordinate plane and shared their techniques for graphing. The lesson concluded with making generalizations about graphing quadratic functions, emphasizing the vertex and axis of symmetry, and evaluating learning by having students draw the graph of a specific quadratic function.

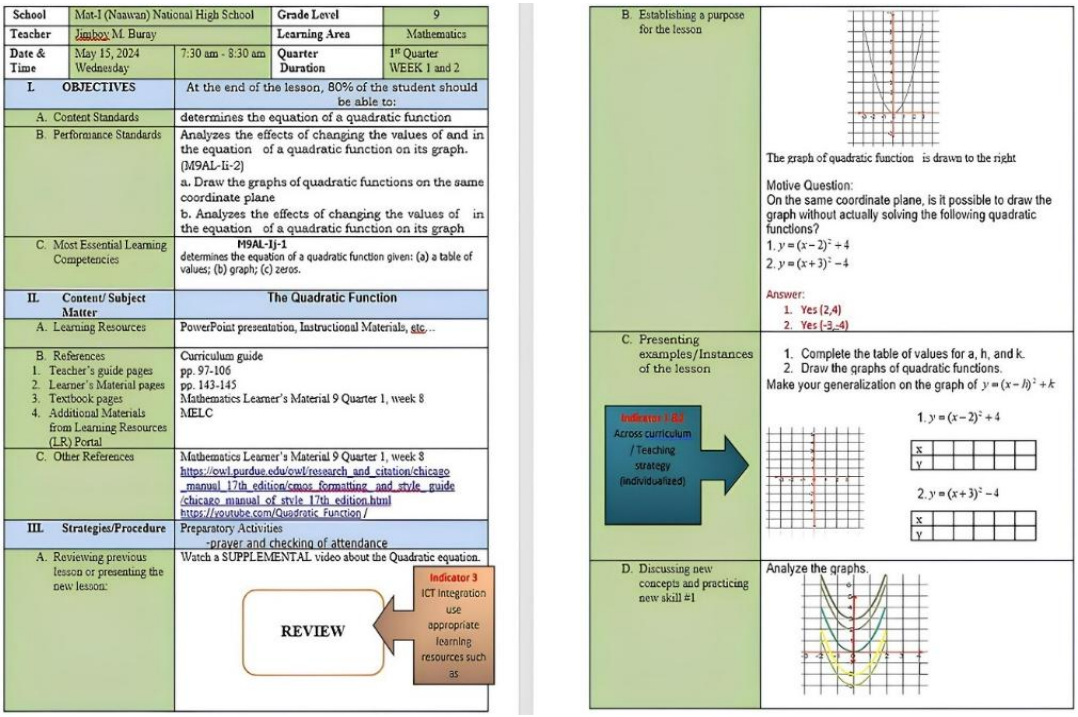

Figure 2. The crafted lesson plan of the mathematics teachers

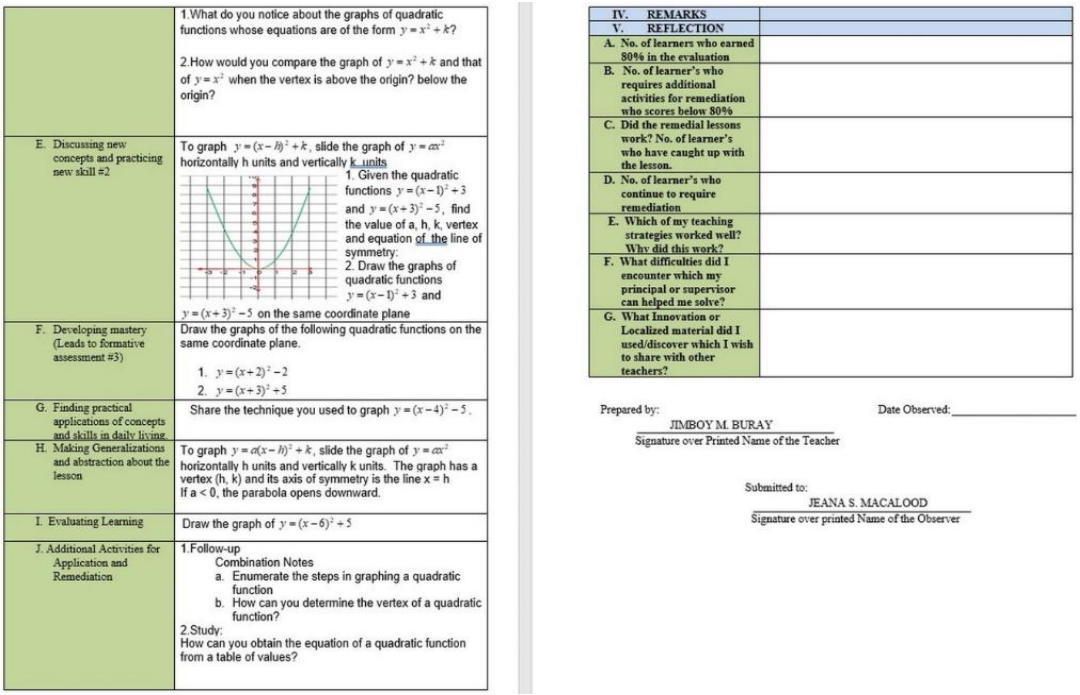

Figure 3. The crafted lesson plan of the mathematics teachers

Additional activities included follow-up questions to reinforce learning and exercises on determining quadratic function equations from tables of values. This comprehensive approach ensured that students not only understood the theoretical aspects of quadratic functions but also gained practical skills in graphing and analysis. Overall, the crafted lesson plan upholds the learning principles of BBL. The effectiveness of lesson plans grounded in BBL can be seen in previous work, noted that training programs aimed at enhancing teachers' skills in developing teaching modules resulted in significant improvements in their instructional practices [37].

4. CONCLUSION

The study highlights the effectiveness of BBL in improving teaching practices by aligning instruction with how the brain naturally learns. While many teachers were somewhat familiar with BBL strategies, their inconsistent application revealed key barriers such as limited time, insufficient resources, and a lack of structured professional development. The training program addressed these gaps by providing sustained support and practical tools, enabling teachers to better integrate BBL into their teaching. It also emphasized the importance of addressing student misconceptions and encouraged interactive, student-centered approaches over traditional lecture methods.

The diversity of the participants enriched the training experience, bringing in varied perspectives from different subject areas and levels of expertise. Teachers found value in collaborative discussions and hands-on strategies that tackled common classroom challenges, especially in science and mathematics. Post-training assessments showed a notable increase in teacher confidence and ability to implement BBL techniques effectively. These findings affirm that well-designed professional development grounded in neuroscience can enhance both teaching quality and student engagement. Future research should examine the long-term impact and scalability of BBL-based programs across diverse educational settings.

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Vanjoreeh A. Madale	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Jamaliah A. Casidar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Manuel B. Barquilla	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Monera A. Salic-Hairulla	✓		✓		✓		✓		✓				✓	
John Jr G. Adil	✓		✓		✓		✓		✓				✓	✓
Arlyn R. Alcopra	✓		✓		✓		✓		✓				✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [VAM], upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Vanjoreeh A. Madale is an associate lecturer in Faculty of the Department of Science and Mathematics Education of Mindanao State University-Iligan Institute of Technology. He holds an undergraduate in Bachelor of Elementary Education major in Science and Health with Master's degree in Science Education majoring in General Science at the same university. Right now, he is pursuing Ph.D. Science Education (Biology). He can be contacted at email: vanjoreeh.madale@g.msuiit.edu.ph.

Jamaliah A. Casidar is a Faculty of Adiong Memorial State College, Ramain, Lanao del Sur, Philippines. She holds a bachelor's degree in Radiologic Technician and a Master's degree in Education. Right now, she is pursuing Ph.D. Science Education (Biology). She can be contacted at email: jamaliah.casidar@g.msuiit.edu.ph.

Manuel B. Barquilla is a professor of the Department of Science and Mathematics Education of Mindanao State University -Iligan Institute of Technology. Dr. Barquilla is a graduate of BS Zoology with Education Units. He has also completed Master of Arts in Science Education (Biology). He holds a doctoral degree in Science Education major in Biology. He can be contacted at email: manuel.barquilla@g.msuiit.edu.ph.

Monera A. Salic-Hairulla is a professor at Mindanao State University-Iligan Institute of Technology with 30 years of experience. She holds a Ph.D. in Science Education majoring in Biology. A consistent DOST scholar, she has held various leadership roles, including Dean of the College of Education and Project Director of the Mindanao State University-Iligan Institute of Technology Department of Science and Technology–Science Education Institute Scholarship Program. An accomplished researcher and educator, she has presented over 50 studies internationally, published in Scopus-indexed proceedings, and received multiple awards for her contributions to teaching and research. She is also a resource speaker and thesis advisor, with active research collaborations locally and internationally. She can be contacted at email: monera.salic@g.msuiit.edu.ph.

John Jr G. Adil is an assistant lecturer in Faculty of the Department of Professional Education of Mindanao State University -Iligan Institute of Technology. He holds an undergraduate in Bachelor of Science in Technology Teacher Education major in Drafting Technology with Master's Degree in Master of Arts in Education majoring in Technical Vocational Teacher Education with focus on Information Communication Technology Education. He can be contacted at email: john.adil@g.msuiit.edu.ph.

Arlyn R. Alcopra is an assistant professor of the Department Professional Education of MSU-Iligan Institute of Technology. Dr. Alcopra is a graduate of BS in Elementary and Secondary Education major in Filipino. She has also completed a Master of Arts Major in Guidance and Counselling in Mindanao State University -Marawi. She holds a doctoral degree in Educational Management. She can be contacted at email: arlyn.alcopra@g.msuiit.edu.ph.