Brain-Based Instructions (BBI): Effects on Grade 10 Students' Achievement in Chemistry

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ABSTRACT

This study aimed to determine the effectiveness of Brain-Based Instruction (BBI) in teaching chemistry on the achievement of Grade 10 students. It employed a quasi-experimental design, featuring pretest and posttest with a control and experimental groups. The participants were from Sultan Guro Memorial National High School in Marantao, Lanao Del Sur, with twenty-five (25) participants in each intact group. Prior to the intervention, no significant differences in mean scores for chemistry achievement between the control and experimental groups were shown. However, after the intervention, significant differences were noted in the mean scores. Hence, this study emphasized BBI as an effective teaching instruction, as it promotes enthusiastic learning experience, optimizes comprehensibility, fosters collaboration and interaction, and develop good study habits. Though, some challenges in BBI were highlighted including difficulties in problem-solving, unavailability of laboratory tools, time-management, and emotional engagement such as disappointment and distressed. Thus, this teaching instruction increased students' achievement in chemistry. It was recommended to school administrators, curriculum developers, and teachers to adopt BBI in their educational practices.

Keywords: achievement, brain-based instruction, chemistry

INTRODUCTION

Chemistry education continues to face persistent challenges in improving students' academic achievement, particularly in rural areas where access to quality instructional resources and innovative teaching strategies is limited. Many classrooms still rely on traditional, teacher-centered approaches that emphasize memorization rather than meaningful understanding. As a result, students often develop low chemistry literacy, weak conceptual understanding, and limited motivation to learn. This situation highlights the need for instructional approaches that address not only cognitive development but also emotional, social, and physical aspects of learning.

In response to these challenges, Brain-Based Instruction (BBI) has been introduced as an emerging approach grounded in neuroscience and cognitive science. BBI is based on the principle that learning becomes more

effective when teaching strategies align with how the brain naturally processes, stores, and retrieves information. Previous studies suggest that intelligence is not fixed but can be developed through experience and practice, as the brain physically changes during learning (Kumar, 2019). Moreover, understanding brain functions such as attention, memory, motivation, and emotional regulation allows educators to design more effective instructional strategies (Amjad et al., 2022).

Furthermore, BBI emphasizes optimal learning conditions that respect the brain's natural processes rather than forcing excessive information intake. It is a student-centered approach that recognizes individual differences in learning styles and promotes active knowledge construction (Akmaliyah et al., 2021; Alhirtani, 2019). It also integrates the brain's five interconnected learning systems such as emotional, social, cognitive, physical, and reflective, which work together to support meaningful learning (Belkacem & Lakas, 2021). In addition, BBI aligns with 21st-century learning goals by enhancing students' ability to access, analyze, and apply information creatively and critically (Handayani & Purwati, 2022; Imanuel et al., 2021). Through these processes, learners are expected to transfer knowledge from short-term to long-term memory while developing higher-order thinking skills.

Despite these theoretical foundations and reported benefits, the practical application of Brain-Based Instruction in chemistry classrooms, especially in rural schools remains limited. Many students in these areas continue to experience difficulties in understanding abstract chemistry concepts due to insufficient instructional support, lack of laboratory resources, and limited exposure to innovative teaching methods. There is also a gap in empirical evidence regarding the effectiveness of BBI in improving chemistry achievement within these contexts.

To address this gap, this study proposes the implementation of Brain-Based Instruction in Grade 10 chemistry classes to determine its effectiveness in improving students' academic achievement. Specifically, it aims to examine whether BBI can enhance students' understanding of chemistry concepts compared to conventional instruction. The study also seeks to explore how BBI influences student engagement, comprehension, and classroom interaction in a rural school setting.

Thus, the effective of this study lies in its potential to contribute to the improvement of science education by providing empirical evidence on the effectiveness of BBI. It is expected that the findings will support teachers in adopting more innovative and brain-compatible teaching strategies. Ultimately, this study aims to bridge the gap in educational opportunities by promoting more effective, inclusive, and meaningful learning experiences for students in rural communities.

METHOD

Research Design

This study employed a quasi-experimental mixed-methods design to determine the effect of Brain-Based Instruction (BBI) on Grade 10 students' achievement in chemistry. The quantitative component utilized a matching-only pretest-posttest control group design adapted from Creswell (2012), wherein two intact classes were matched based on their previous science grades and assigned as the experimental and control groups. The experimental group received Brain-Based Instruction (BBI), while the control group received Conventional Instruction (CI). Pretest and posttest scores were used to measure students' achievement. The qualitative component explored students' perceptions of BBI through interviews, journals, and teacher-observer notes to support and triangulate the quantitative findings.

Research Participants

The participants were Grade 10 students of Sultan Guro Memorial National High School during the School Year 2023–2024. Two intact classes were selected and matched according to their first, second, and third quarter science grades. Through random assignment by drawing lots, one class was designated as the experimental group and the other as the control group. Twenty-five matched students from each group were included in the statistical analysis, while all students participated in the instructional activities.

Research Instruments

The primary quantitative instrument was the Chemistry Achievement Test (CAT), developed from the Grade 10 K–12 Science Curriculum with topics such as Gas Laws, Biomolecules, and Chemical Reactions. Initially consisting of 90 multiple-choice items, the test underwent content validation by chemistry experts and pilot testing. Item analysis and reliability testing reduced the instrument to 70 items, yielding a Cronbach's alpha coefficient of 0.69. Qualitative data were gathered through researcher-developed interview guides, students' reflective journals, and teacher-observer notes. These instruments were used to collect participants' experiences and perceptions regarding the instructional approaches and to triangulate the study findings.

Data Gathering Procedure

The study was conducted in three phases: pre-intervention, intervention, and post-intervention. During the pre-intervention phase, the CAT, interview guides, and lesson plans were developed, validated, and pilot-tested. The experimental group's lesson plans were modified based on the seven stages of Brain-Based Instruction proposed by Jensen (2008): pre-exposure, preparation, initiation and acquisition, elaboration, incubation and memory coding, verification and confidence check, and celebration and integration. The control group followed conventional teacher-centered instruction.

During the intervention phase, both groups took the CAT as a pretest. The experimental group received BBI-integrated lessons, while the control group received conventional instruction. The intervention lasted for six weeks and covered the Chemistry competencies in the fourth quarter curriculum. Classroom observations were conducted to ensure adherence to the lesson plans.

During the post-intervention phase, the CAT was administered as a posttest to both groups. Individual interviews were then conducted with 10 volunteered students to gather their perceptions and experiences regarding the instructional strategies employed.

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Frequency and percentage were used to describe participant characteristics, while mean scores summarized students' achievement levels. An independent-samples t-test was employed to determine significant differences between the achievement scores of the experimental and control groups. Qualitative data from interviews, journals, and teacher-observer notes were analyzed using thematic analysis. Emerging themes were identified and interpreted to explain students' perceptions of Brain-Based Instruction and to support the quantitative findings.

Ethical Considerations

Ethical clearance and permission from the school administration were secured before conducting the study. Informed consent was obtained from all participants, and participation was voluntary. Confidentiality and anonymity were maintained through data coding, and all collected information was used solely for research purposes. Participants were informed of their right to withdraw from the study at any stage without penalty.

FINDINGS AND DISCUSSION

The findings of this study present the effectiveness of Brain-Based Instruction (BBI) on Grade 10 students' achievement in chemistry. Table 1 shows the comparison of control and experimental groups before and after the intervention.

Table 1:
Mean and Standard Deviation of the Control and Experimental Groups of Students' Achievement in Chemistry before and after the intervention

Period	Groups	N	Mean	Standard Deviation
Before intervention	Experimental	25	19.36	3.48
	Control	25	19.76	4.00
After intervention	Experimental	25	50.40	8.53
	Control	25	26.80	6.24

As shown in Table 1, the two groups demonstrated comparable levels of achievement before the intervention. Both groups had almost the same level of performance before the intervention, with the experimental group (M = 19.36, SD = 3.48) and the control group (M = 19.76, SD = 4.00), indicating that students initially had limited knowledge in chemistry. After the intervention, both groups improved; however, the experimental group obtained a much higher mean score (M = 50.40, SD = 8.53) compared to the control group (M = 26.80, SD = 6.24). This indicates that while both groups learned, the experimental group showed a significantly greater improvement.

This study showed a notable improvements in students' achievement in chemistry during the implementation of BBI in the experimental group. It revealed that students who experienced BBI exhibited a significant increase in their mean scores, rising from a pre-intervention score of 19.36 to an impressive post-intervention score of 50.40. This corroborates to the study conducted by Bada and Jita (2022) indicating that BBI positively influenced students' achievement in the science classroom. Hence, a number of studies on the use of BBI in classrooms indicated that it positively impacted students' achievement. Particularly, Al-Tarawne et al. (2021), Alanazi (2020), Saleh and Subramaniam (2019), Wijayanti et al. (2021), and Riskiningtyas and Wangid (2019) demonstrated that this approach improved students' achievement in primary and secondary school science, including core subjects such as biology, chemistry, physics, and mathematics.

In contrast, the control group, which was taught by conventional instruction, demonstrated a slightly improvement in mean scores, from 19.76 to 26.80. This suggested that while conventional instruction can yield positive outcomes, they may not be as effective in promoting significant academic growth as innovative as BBI. The consistent but limited progress in the control group underscored the need for instruction that actively engage students and cater to their diverse learning preferences. Infact, Cave et al. (2022) emphasized that while conventional instruction, such as lectures, were beneficial for large groups, they often led to reduced student participation, making active learning more challenging compared to student-centered methods like problem-solving strategies. To further determine whether the differences between the groups were statistically significant, a t-test was conducted on the students' achievement scores before and after the intervention. This was used to examine whether the observed differences in mean scores between the groups were due to the intervention rather than chance as shown in Table 2 below.

Table 2:
t-test and p Values on the Comparison of Control and Experimental Groups of Students' Chemistry Achievement Mean Score before and after Intervention

Period	Group (n=25)	Mean Score	SD	t-value	p-value	Remarks
Before intervention	Experimental	19.36	3.48			Not
	Control	19.76	4.00	-.38	.71	significant
After intervention	Experimental	50.40	8.53			
	Control	26.80	6.24	11.17	.00	Significant

Before the intervention, there was no significant difference between the two groups (t = -0.38, p = 0.71), indicating that both groups started at the same level of achievement. This confirms that students had similarly low prior knowledge in chemistry, which is consistent with previous observations that chemistry is often perceived as a difficult subject (Cave et al., 2022). However, after the intervention, a significant difference was observed (t = 11.17, p = 0.00), indicating that the improvement in the experimental group was not due to chance but was influenced by the intervention. This result confirms the effectiveness of Brain-Based Instruction in improving students' achievement in chemistry and supports Kumar (2019), who emphasized that brain-based approaches enhance learning by aligning instruction with natural brain processes.

The present study emphasized that students' improved achievement in chemistry was largely attributed to the effectiveness of Brain-Based Instruction (BBI), increased conceptual understanding, and collaborative learning among students. BBI promoted interactive learning by encouraging learners to connect new concepts with prior knowledge, which improved comprehension, retention, and critical thinking skills. As students developed a deeper understanding of chemistry concepts, they became more active in class discussions, asked more questions, and showed greater confidence in learning. This increased engagement also encouraged teachers to adopt more interactive and responsive teaching strategies, further strengthening the learning process. In addition, teamwork during group activities played a key role in student success, as it allowed learners to share ideas, exchange perspectives, and collaboratively solve problems, leading to deeper conceptual understanding.

These findings are supported by related literature emphasizing the importance of collaborative and active learning strategies in improving student achievement (Kumar, 2019; Kara, 2021). However, the study also highlights why students in the control group performed lower, as chemistry learning is often hindered by difficulties in understanding abstract concepts and chemical processes (Ayildiz et al., 2023). Students frequently struggle with problem-solving due to weak foundational knowledge, leading to frustration and low confidence, especially in complex tasks. Studies also show that many learners rely on memorization rather than conceptual understanding, which limits their long-

term achievement in chemistry (Samosa, 2021). Overall, the findings suggest that the integration of BBI, supported by guided instruction, cooperative learning, and strong teacher facilitation, can significantly improve students' understanding, engagement, and academic performance in chemistry.

Hence, the study clearly shows that Brain-Based Instruction (BBI) is an effective instructional approach that enhances students' achievement in chemistry that promotes enthusiastic learning experience, optimizes comprehensibility, fosters collaboration and interaction, and develop good study habits. This results in a more active learning environment compared to conventional instruction, which tends to limit interaction and student involvement. However, despite these benefits, students also encountered challenges during the implementation of BBI, including difficulties in problem-solving, time constraints, lack of laboratory materials, and emotional engagement such as disappointment and distressed. As noted by Şahin (2020), student-centered approaches can be demanding because learners take greater responsibility for their learning process, requiring adaptation from both teachers and students. Thus, BBI has strong potential to improve chemistry learning outcomes in a classroom setting.

CONCLUSION

This study concludes that Brain-Based Instruction (BBI) is an effective teaching approach in improving Grade 10 students' achievement in chemistry. The experimental group showed a significantly greater improvement in post-test scores compared to the control group, and the difference between the groups was found to be statistically significant after the intervention. These results indicate that BBI is more effective than conventional instruction in enhancing students' understanding of chemistry concepts.

Furthermore, BBI promotes more active, engaging, and meaningful learning experiences by improving participation, comprehension, collaboration, and study habits. However, its implementation also involves challenges such as limited resources, time constraints, and students' adjustment to more active learning roles. Despite these challenges, the findings suggest that BBI has strong potential to improve chemistry learning outcomes and support more effective classroom instruction.

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REFERENCES

Akmaliyah, Hudzaifah, Y., Ulfah, N., & Pamungkas, M. I. (2021). Child friendly teaching approach for Arabic language in Indonesian Islamic boarding school. *International Journal of Language Education,* 5(1), 501–514. https://doi.org/10.26858/IJOLE.V5I1.15297

Alanazi, F. H. (2020). Brain-based learning as perceived by Saudi teachers and its effect on chemistry achievement of 7th graders. *Journal of Baltic Science Education*, 19(6), 864–874. https://doi.org/10.33225/jbse/20.19.864

Alhirtani, N. A. K. (2019). The use of modern teaching methods in teaching Arabic language at higher education phase from the point view of Arabic language professors: A case of a Premier University. *International Education Studies*, 13(1), 32. https://doi.org/10.5539/ies.v13n1p32

Al-Tarawneh, A., Altarawneh, A. F., & Karaki, W. K. (2021). Effect of brain-based learning in developing spatial ability of ninth grade students with low achievement in mathematics. *Journal of Educational and Social Research*, 11(5), 141-150.

Amjad, A. I., Habib, M., & Saeed, M. (2022). Effect of brain-based learning on students' mathematics performance at elementary level. Pakistan Journal of Social Research, 4(3), 38-51. https://doi.org/10.52567/pjsr.v4i03.684

Ayıldız, Y., Tarhan, L., & Gil, A. (2023). Comparing the effectiveness of the learning material and the learning method in students' achievement in chemistry lesson on chemical changes. Research in Science & Technological Education, 41(4), 1372-1393. https://doi.org/10.1080/02635143.2022.2086535

Bada, A., & Jita, L. (2022). Integrating brain-based learning in the science classroom: A systematic review. *International Journal of Pedagogy and Teacher Education*, 6(1), 25-37. https://dx.doi.org/10.20961/ijpte.v6i1.57377

Belkacem, A. N., & Lakas, A. (2021). A case study on teaching a brain–computer interface interdisciplinary course to undergraduates. *Learning Media Arabic: Springer.*

Cave, T., Ludwar, J., & Williams, W. (2021). *Brain-based Learrning*. University of Lethbridge. https://education.alberta.ca/apps/aisi/literature/pdfs/bbsed_learning.pdf

Creswell, J.W. (2012). Educational research: planning, conducting, evaluation of quantitative and qualitative research. Pearson Press.

Handayani, B. S., & Purwati, N. (2022). The effectiveness of brain-based

learning model (bbl) integrated with the whole brain teaching (wbt) model toward students' retention. Biosfer, 15(1), 36–43. https://doi.org/10.21009/biosferjpb.26030

Imanuel, Waluya, S. B., & Mariani, S. (2021). The effectiveness of brain-based learning assisted by schoology towards students' creative thinking and self-efficacy. Journal of Primary Education, 10(3), 274–281. https://doi.org/10.15294/jpe.v10i3.34902

Jensen, E. (2008). *Brain-Based Learning: The new paradigm of teaching.* Thousand Oaks, CA: Corwin.

Jensen, E., & McConchie, L. (2020). *Brain-based learning: Teaching the way students really learn.* Corwin Press.

Kara, N., 2021. A systematic review of the use of serious games in science education. Contemp. Educ. Technol., 13 (2), ep295.

Kumar, P. (2019). Brain based learning, an innovative strategy for effective learning. *International Journal of Advanced Research and Review*, 4(4), 18-22.

Riskiningtyas, L., & Wangid, M. N. (2019). Students' self-efficacy of mathematics through brain-based learning. *Journal of Physics: Conference Series,* 1157(4). https://doi.org/10.1088/1742-6596/1157/4/042067

Şahin, Ş. (2020). Öğrenci, öğretmen ve müdürlerin sevgi, demokrasi ve öğrenci merkezli eğitim algıları (Yayınlanmamış doktora tezi). *Düzce Üniversitesi Sosyal Bilimler Enstitüsü, Düzce*.

Sahito, Z., & Väisänen, P. (2019). Teachers' job satisfaction in developing countries: A literature review. *European Journal of Cultural Studies,* 5, 769–793. http://dx.doi.org/10.1002/rev3.3159

Saleh, S., & Subramaniam, L. (2019). The impact of mindfulness meditation on academic performance in high school students. *Journal of Educational Psychology*, *111*(3), 456-472.

Samosa, R.C. (2021). Mobile virtual laboratory as innovative strategy to improve learners' achievement, attitudes, and learning environment in teaching chemistry. International Journal of Multidisciplinary: Applied Business and Education Research 2(5), 398-400. https://doi.org.10.11594

Wijaya, A. (2021). Efektivitas penerapan metode demonstrasi pada materi koloid dalam meningkatkan hasil belajar peserta didik kelas XII IPA MA DDI entrop kota jayapura. *Jurnal Honei*, 3(2), 56-67. https://doi.org/10.47655/honai.v3i2.38

Wijayanti, K., Khasanah, A. F., Rizkiana, T., Mashuri, Dewi, N. R., & Budhiati, R. (2021). Mathematical creative thinking ability of students in

treffinger and brain-based learning at junior high school. *Journal of Physics: Conference Series*, 1918(4), 042085. https://doi.org/10.1088/1742-6596/1918/4/042085