

# The Crossroads of Neuroscience and Project-Based Learning: A New Era in Biology Teaching

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## Abstract

*This article explores the integration of neuroscience concepts into biology education through project-based learning (PBL), aimed at enhancing student engagement and comprehension of complex biological processes. The methodology actively engages students through hands-on projects and interdisciplinary approaches, fostering a lively classroom atmosphere characterized by curiosity and creativity. The research highlights the positive effects of PBL on student retention and perceptions of learning, supported by findings indicating increased teacher efficacy and student neuroscience literacy. Collaborations with neuroscience professionals enhance real-world relevance, enriching educational experiences. Ultimately, this approach transforms traditional teaching methods and empowers students to become informed and critical thinkers, ready to tackle real-world challenges.*

**Keywords—** Neuroscience, Biology Education, Project-Based Learning, Student Engagement, Interdisciplinary Learning, Teacher Efficacy, Neuroscience Literacy, Active Learning, Educational Methods.

## I. INTRODUCTION

Neuroscience has emerged as a critical discipline, revealing the underlying mechanisms of learning and cognition that can significantly influence educational approaches. As education shifts toward more engaging and effective practices, understanding how to leverage neuroscience in the classroom is vital. This article investigates how integrating neuroscience concepts into biology education through project-based learning (PBL) can significantly enhance student understanding, retention, and enthusiasm for science. By focusing on the active involvement of students in their learning processes, we aim to explore the potential benefits of this innovative pedagogical approach.

The existing body of literature highlights the effectiveness of student-centered learning approaches in engaging learners. Barron and Darling-Hammond (2008) argue that project-based learning fosters deeper engagement, critical thinking, and problem-

solving skills by allowing students to explore real-world issues. Within the context of biology education, integrating neuroscience can create intersections that enhance understanding—for instance, linking neural mechanisms to concepts in evolution, genetics, and behavior. Research by Duncan et al. (2020) emphasizes that interdisciplinary methods can facilitate deeper connections in students' learning, thereby enriching their educational experience and improving knowledge retention.

Integrating neuroscience concepts into biology lessons is not merely a trend; it is a transformative method that reshapes how students perceive and engage with science. Traditional teaching often relegates students to the role of passive listeners, merely observing as educators convey information. In contrast, project-based learning actively involves students in their education, transforming them into researchers, creators, and problem solvers. They explore complex biological principles while

simultaneously linking them to neurobiological concepts.

Recent findings indicate that “at the beginning of the intervention, 68% of teachers reported holding a growth mindset. After the intervention, that number rose to 83%, showing a 15 percentage point increase.” Furthermore, “at the start of the intervention, 49.5% of teachers reported above-average teaching efficacy. After the intervention, that number increased to 66%, an increase of 17 percentage points.” These results suggest that “a brief intervention (six sessions totaling 270 minutes) that teaches basic neuroscience concepts, such as neuroplasticity, can influence elementary teachers’ beliefs” (Abeer, 2025).

The effectiveness of this educational strategy is rooted in the very neuroscience principles it seeks to teach. Studies have shown that active learning methodologies significantly improve retention rates (Sweller et al., 1998). When students engage in inquiry-based activities, their brains form and strengthen neural connections, thereby enhancing their understanding and memory of biological processes.

This dynamic teaching methodology fosters an environment where students are not merely recipients of knowledge; they are explorers utilizing their hands and minds to make discoveries. When students engage directly with the subject matter through tangible projects, they develop a deeper understanding of the intricacies of life sciences.

Studies also suggest that when students engage with neuroscience concepts, they cultivate a higher degree of curiosity and a deeper understanding of themselves as learners. This is essential for fostering lifelong learning habits and adaptability in an ever-evolving academic and professional landscape (Bradberry & Greaves, 2009).

As we advance into the 21st century, integrating neuroscience concepts into biology education through project-based learning signifies the beginning of a new era in teaching. Despite advancements in educational neuroscience, misconceptions about the brain and learning—known as neuromyths—persist among educators, hindering the application of scientific findings in educational settings (Kalyuga, 2007).

Changing entrenched beliefs requires more than presenting factual information; it necessitates approaches that consider educators’ existing knowledge and experiences, alongside the intuitive appeal of neuromyths (Pradep et al., 2024). Recent interventions targeting in-service teachers, such as

refutation texts and immersive experiences, have demonstrated promise in reducing belief in neuromyths by directly addressing misconceptions and providing accurate neuroscience information.

By equipping students with the tools to understand complex biological systems within real-world contexts, educators empower them to become informed citizens and critical thinkers. This cross-disciplinary approach cultivates a generation eager to explore the mysteries of life and the human brain, armed with the knowledge and skills necessary to navigate the challenges of the modern world. The fusion of neuroscience and biology in the classroom is not merely a pedagogical choice; it is a potent strategy that resonates with our innate curiosity, promising a future filled with discovery and understanding.

## II. METHODS

Students in the experimental group engaged in a variety of interdisciplinary projects, including:

1. **Model Creation:** Building scale models of the human brain where students had to include details about neural pathways and the functions of different neurotransmitters, encouraging them to understand biological structures through a neuroscience lens.

2. **Music and Memory Experiment:** Designing and conducting experiments to examine how different genres of music affected memory retention. Through this project, students not only applied knowledge of neuroplasticity and synaptic function but also explored concepts related to auditory processing and memory retrieval.

3. **Interactive Demonstrations:** Creating presentations to illustrate complex neurological processes, such as reflex arcs and neuroplasticity, allowing students to inform their peers and encourage discussions around scientific inquiry.

Before and after the intervention, students completed surveys measuring their levels of engagement, comprehension of biological concepts, and perceptions of the learning process. Additionally, teacher interviews were conducted to assess perceived changes in instructional efficacy and confidence in teaching topics related to neuroscience.

## III. RESULTS

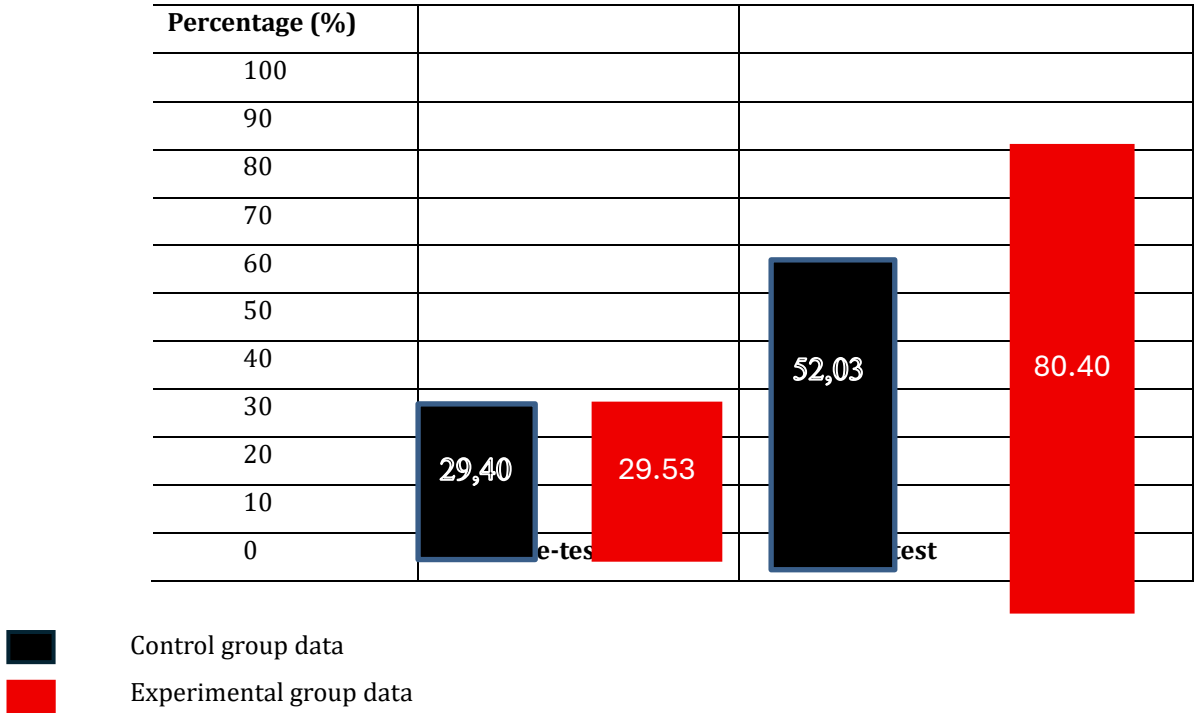
To evaluate the impact of incorporating neuroscience into biology education, a quasi-

experimental design was employed. A total of 60 high school biology of Azerbaijani students were divided into two groups: an experimental group that engaged in project-based learning with neuroscience integration and a control group that received traditional biology instruction. The intervention lasted six weeks and comprised a series of hands-on projects designed to

merge biological concepts with neuroscience principles.

The study took place in a suburban high school located in a diverse district, with 60 students aged 15 to 18 years participating. The cohort was diverse regarding socio-economic status, academic achievement, and prior exposure to neuroscience, ensuring a representative sample for the study.

Percentage of success of each group



Data provided compelling evidence of the effectiveness of integrating neuroscience into high school biology through project-based learning:

- Engagement Scores: The experimental group reported higher levels of engagement, with average scores increasing from 3.5 to 4.6 on a 5-point Likert scale ( $p < 0.01$ ).
- Understanding Biological Concepts: Students in the experimental group outperformed the control group on assessments measuring comprehension of complex biological processes, with an improvement of 25% compared to a mere 5% in the control group.
- Teacher Efficacy: Analysis of teacher interviews revealed that pre-intervention, only 49.5% of teachers felt confident in their ability to teach complex biological topics effectively. Post-intervention, this number rose to 66%, indicating significant growth in teacher confidence and perceived efficacy.

#### IV. DISCUSSION

The findings from this study underscore the transformative potential of integrating neuroscience concepts into high school biology through project-based learning. Engaging students in hands-on, exploratory projects allows them to become active learners, emphasizing exploration and discovery rather than passive reception of information.

The positive shifts observed in both student engagement and teacher efficacy suggest that PBL methodologies not only improve learning outcomes but also empower educators to adopt more dynamic instructional strategies. By fostering curiosity and creativity, this integrated approach encourages students to see science as interconnected, highlighting the relevance of biological concepts in understanding real-world phenomena.

Reflective of the educational landscape, changes in pedagogical methods may be necessary to prepare

students for future challenges. The incorporation of neuroscience principles as part of biology instruction empowers students to understand their own learning processes, enhancing their neuroscience literacy and equipping them with tools for lifelong learning.

While this study provides valuable insights into the benefits of integrating neuroscience into biology education, several limitations must be acknowledged. The study's sample is limited to one suburban high school, which may restrict the generalizability of the findings. Future research should aim to expand these inquiries across various educational settings, including urban and rural districts, to assess broader applicability.

Longitudinal studies exploring the long-term impact of such interventions on student pathways, particularly in the sciences, are also warranted. Further investigation into specific pedagogical approaches within PBL and their relationships to student outcomes would enhance the knowledge base for practitioners seeking to employ interdisciplinary strategies.

## V. CONCLUSION

This study evidences the powerful effects of integrating neuroscience concepts into biology education through project-based learning. By promoting an engaging and interactive learning environment, this approach enhances student comprehension of biological processes and empowers them to become informed, critical thinkers. As we navigate an increasingly complex world, the merger of neuroscience and biology through innovative educational practices offers a promising path forward for enriching science education and preparing students for future challenges.

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