Breaking Barriers: Promoting Motivation, Engagement, and Learning Success among Biology Undergraduates from Minority Backgrounds

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Abstract

This research presents an in-depth exploration of the transformative potential of hands-on learning (which would be used interchangeably with the term ECP-Experiment Centric Pedagogy) in the domain of biology education, with a focus on student engagement and academic achievement. Over three semesters, students enrolled in three biology courses (BIO 103, BIO 201, and BIO 202) participated in a hands-on learning approach that integrated various hands-on activities and experiments. In parallel, participants in a non-ECP group were exposed to conventional teaching methods.

The keystone of this pedagogical transformation was the "Heart Rate" experiment, wherein students utilized a mobile application to quantify heart rate fluctuations following various physical activities. The study employed pre- and post-surveys to assess student engagement, while pre- and post-signature assessments were administered to gauge their understanding of the experiment's core concepts. Project assignments were used to evaluate practical application and understanding.

Using statistical software like SPSS and Excel, meticulous data analysis was conducted to provide a comprehensive look at the students' performance over these three semesters.

Results showed that students who participated in hands-on learning activities demonstrated significantly higher levels of engagement and performance than those in the non-ECP group. The data showed marked improvements in student engagement and learning outcomes.

This study builds upon prior work that investigated the implementation of an experiment-centric pedagogy aimed at enhancing student motivation, learning, and critical thinking skills within biology. It contributes to the discourse on the transformative potential of this pedagogical approach in STEM education. The findings suggest that this approach can help create a more engaging and meaningful learning experience for biology students, leading to improved outcomes in academic achievement and persistence.

Keywords: Hands-on learning, student engagement, academic achievement, pedagogical innovation, Biology Education, Student Motivation, STEM education, higher education.

Introduction

In the ever-evolving field of education, the traditional methods of biology instruction are being reevaluated due to concerns about declining student engagement and academic achievement [1]. The conventional lecture-based approach, prevalent for years, is a worrying trend of disengaged and unmotivated students [2], struggling to find interest in new concepts, jeopardizing their learning potential and academic success. This decline in engagement and academic achievement is particularly noteworthy as the phenomenon can be attributed to many factors, ranging from personal or family issues to ineffective teaching methods that fail to spark curiosity and ignite a passion for learning. Innovative instructional strategies are of vital importance in the face of this challenge to boost academic results and rekindle student involvement.

Amidst these challenges, there is a growing recognition of the need for innovative pedagogical approaches [3] to reignite students' passion for learning [4]. This research explores the transformative potential of hands-on learning, a powerful educational philosophy that places the learner at the center of the educational experience. Through experimentation and hands-on interaction, this pedagogy engages students in the dynamic world of active learning instead of only depending on the passive transfer of information. This enhances a deeper understanding of the course material and cultivates critical thinking, problem-solving, and collaboration skills – vital tools for their academic journey and beyond.

Literature Review

In recent years, there have been a couple of research geared towards evaluating students' learning, motivation, and achievement in the STEM discipline by adopting both the traditional-lecture approach and the Experiment-based teaching approach. A significant body of literature supports the notion that hands-on learning can revolutionize traditional education models. In their study [5] Kibga et al., explored the benefits of hands-on activities and experiments in fostering a deeper understanding of scientific concepts. The shift from passive learning to active engagement has been associated with increased student motivation, critical thinking skills, and overall learning outcomes [6]. Moreover, research in STEM education has emphasized the importance of hands-on learning in cultivating practical skills and preparing students for real-world applications [7]. This study builds upon this existing body of knowledge, aiming to contribute to the growing discourse on the transformative potential of hands-on learning in the context of biology education.

Experiment-Centric Teaching Pedagogy:

The Experiment-Centric Pedagogy (ECP) has emerged as a promising solution to the challenges faced in conventional biology education. ECP emphasizes hands-on learning experiences, utilizing affordable, safe, and portable electronic instrumentation systems to actively engage students in experiments [8]. This pedagogical shift aligns with the call for innovative approaches in STEM education [9], and its effectiveness in raising student achievement levels has been well-documented [10]–[13] . The ECP becomes a focal point in this research, exploring its potential to enhance student engagement and academic achievement in the context of biology courses.

The potential of experiment-centric pedagogies in enhancing student engagement and learning has been supported by several studies. For example, Duran et al in their paper [14] argued that incorporating real-world, inquiry-based experiments into science curricula can cultivate critical thinking skills, enhance problem-solving abilities, and stimulate a deeper understanding of scientific concepts. There has also been several studies [5], [15], [16] that have emphasized the positive impact of hands-on science activities on student engagement and curiosity, particularly for students who typically struggle with traditional lecture-based approaches. These findings strongly support the premise of this research, which explores the transformative potential of an experiment-centric pedagogy in the context of biology education.

Student Engagement and Academic Achievement:

How can we encourage student engagement and academic achievement in ‘'today's educational environment? This is a crucial question that educators and researchers face, as various factors, such as family, school, and personal challenges, can negatively affect 'students' motivation and participation in learning [17]. This literature review delves into the intricate relationship between student engagement and academic achievement, highlighting the need for targeted interventions to address the underlying issues that impede effective learning experiences.

The correlation between student engagement and academic achievement is well-established in educational research. A meta-analysis by Hao et al., [12] concluded that a positive and significant relationship exists between student engagement and various measures of academic success, including exam grades, course completion rates, and overall GPA. Similarly, the studies [18]–[20] revealed the crucial role of student engagement in fostering higher academic performance and cultivating a sense of accomplishment and satisfaction with learning. The current study contributed to the body of knowledge by investigating the impact of a hands-on learning approach on student engagement and academic achievement in a biology class setting.

Hands-on Learning and its Impact on College Students:

Hands-on learning, a pedagogical approach emphasizing active engagement and direct experience, has garnered significant attention for its potential to enhance student learning and development. Hands-on learning, characterized by hands-on activities and real-world applications, has become an effective educational approach [21]–[23]. Previous studies [24], [25] have shown that this approach promotes higher levels of student engagement, critical thinking skills, and overall learning outcomes. The current study contributed to the discourse on the transformative potential of hands-on learning in the context of biology education.

Massachusetts Institute of Technology (MIT) Digital Learning Lab, in one of their articles [26], conceptualized hands-on learning as a cyclical process that encompasses concrete experience, reflective observation, abstract conceptualization, and active experimentation. A few studies have shown how hands-on learning improves student outcomes, including motivation and engagement, conceptual knowledge, critical thinking, and problem-solving development. To further substantial the ongoing discussions, some studies [27], [28] have found that hands-on learning approaches led to significant improvements in student learning outcomes across various disciplines, including science, technology, engineering, and mathematics (STEM). This research project builds upon this existing body of evidence to explore the effectiveness of a hands-on learning approach in biology education.

Theoretical Framework

Grounded in constructivist theories of learning, propounded by Jerome Bruner in 1966 and Lev Vygotsky in 1968 which suggests that individuals can learn best when they interact with others, this research adopts a theoretical framework that posits learning as an active process where individuals construct knowledge through their experiences [29]. Hands-on learning aligns with these theoretical perspectives by allowing students to engage directly with the subject matter, fostering a more profound understanding and retention of knowledge. Incorporating hands-on activities, such as the "Heart Rate" experiment, serves as a vehicle for students to apply theoretical concepts in practical contexts, bridging the gap between abstract ideas and real-world applications.

The process of learning is personal and at the same time dynamic. Educators must understand how new skills are developed, new knowledge is acquired, and new behaviors, morals, attitudes, and values are instilled. Learning theories describe the structure of how people learn. Research has been conducted to discover how people learn, and theorists have developed various theories on how learning occurs.

1. Self-Determination Theory (SDT): The SDT, as shown in Figure 1, is a macro-theory that proposes that people are motivated by three intrinsic needs: autonomy, relatedness, and competence. The theory posits that when these needs are met, individuals will be more likely to be engaged and motivated in their activities [30].

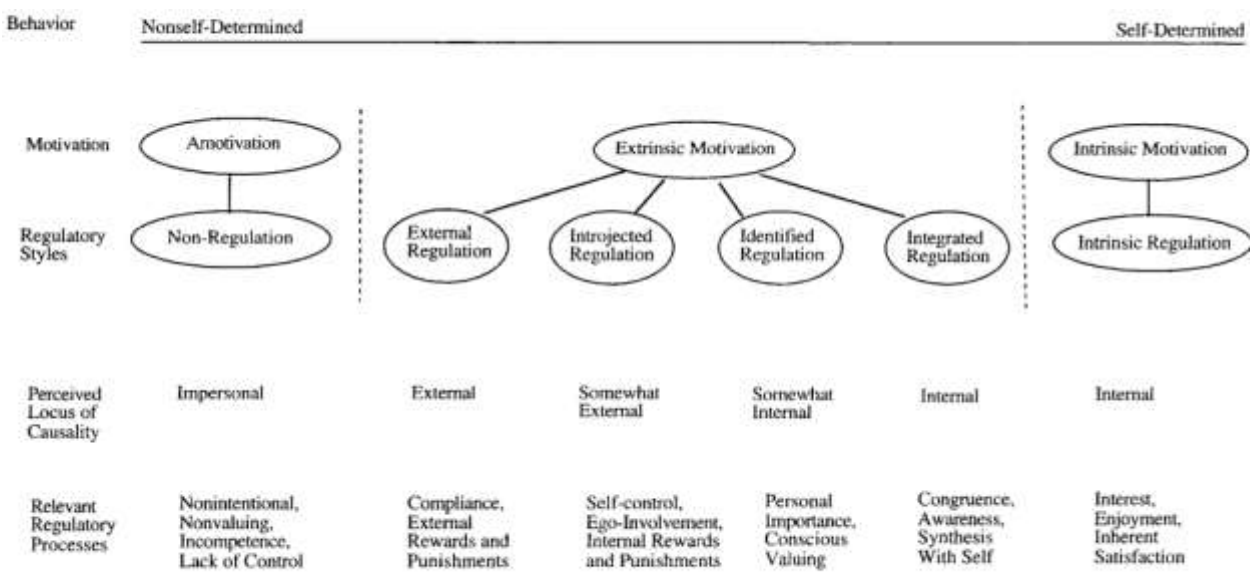

Figure 1: The Self-Determination Continuum [30]

2. Engagement Theory: Engagement theory is a micro-theory which proposes that student engagement can be measured through three different types of activities: behavioral (e.g., attentiveness, effort, work completion), emotional (e.g., interest, enthusiasm, motivation), and cognitive (e.g., reasoning, problem-solving, critical thinking) [31], [32].

Experiment-centered pedagogy integrates problem-based activities and constructivist instruction by allowing students to actively participate in the learning process via the construction of new knowledge or understanding through building on their prior experiences and understanding. According to Constructivism, knowledge acquisition occurs amid four assumptions: (i) Learning entails active cognitive processing; (ii) learning is adaptive; (iii) learning is subjective rather than objective; and (iv) Learning entails both social/cultural and individual processes[33].

Research Questions

The central question for this research is, "How does hands-on learning impact student engagement and academic achievement in biology education?" This has furthermore curated three important questions which form the base rock of this research. These questions are:

1. How does the implementation of hands-on learning approaches, specifically centered around hands-on activities and experiments, impact student engagement in biology education?
2. What are the effects of hands-on learning on student academic achievement, particularly in understanding core concepts and practical application in biology courses?
3. How does hands-on learning contribute to enhancing critical thinking skills, problem-solving abilities, and motivation among biology students potentially improving their overall learning outcomes in STEM education?

Research Methodology

We designed this research to explore how hands-on learning can enhance student's learning in select Biology classes. Our focus was on three Biology courses (BIO 103, BIO 201, and BIO 202), and we utilized various assessment tools to measure student performance and engagement. By doing that, we aim to reveal the nuanced effects of hands-on learning on students learning and interest in Biology.

The study is a quantitative descriptive study that focuses on a particular group in a pre-test and post-test design. This study adopted purposeful sampling in selecting the classes where ECP would be implemented. The inclusion criteria for participants are full-time students enrolled in foundational courses in Biology and willingness to allow classroom observation of activities as well as recording these activities. Ethical clearance was issued by the Morgan State Institutional Research Board (IRB) for the cause of this research. Students were informed before the experimental or hands-on session, and only those who provided consent participated in this study.

The study proposed two experiments; fermentation in plants and heart rate, to illustrate certain biological concepts effectively. After reviewing these experiments, the heart rate experiment was selected to teach the concept of the cardiovascular system. The study used a readily available app that students could access on their hands-on devices to measure their heart rates in and out of class. This app was used to demonstrate to the students some critical and difficult-to-understand aspects of the concepts of the cardiovascular system in a way they could relate more effectively.

After identifying these concepts, experiments utilizing electronic instruments are developed and implemented. The Motivated Strategies for Learning Questionnaire (MSLQ) was used to assess key constructs related to student success, such as motivation, epistemic and perceptual curiosity, and self-efficacy [34], [35]. Student success was determined by the academic performance of students who received ECP doses in different classes and across the gender spectrum. Furthermore, the fundamentals of ECP and the classroom observation protocol are implemented to effectively integrate ECP into the Biology Discipline.

Student participation in ECP was evaluated using the Classroom Observation Protocol for Undergraduate STEM(COPUS), developed by Smith et al. [36]. COPUS was used to accurately describe how instructors and students spend their time in the classroom. This pedagogically proven evaluation instrument, COPUS, also provides feedback to teachers/instructors on their teaching methods' efficiency to pinpoint areas needing professional growth. University professors can rely on this classroom observation protocol, which has 25 codes with only two categories ("What the students are doing" and "What the instructor is doing"). Velasco et al. [37] also suggested using a bar chart to analyze the observation results. This bar chart reveals the percentage of behaviors, calculated as percentages of 2-minute intervals in a class period during which individual behaviors were observed, as well as the percentage of codes describing the nature of interaction-coded intervals co-coded with codes for the nature of verbal interactions. A signature assignment given both before and after the module was used to gauge each student's level of understanding. The capacity to design and conduct experiments or test hypotheses, analyze, interpret data, and apply scientific judgment to make conclusions were all skills developed into instruments to assess student learning outcomes.

Participants

Across three consecutive semesters (Fall 2022, Spring 2023, and Fall 2023), the study engaged 251 undergraduate students enrolled in three distinct biology courses: BIO 103, BIO 201, and BIO 202. These were students from various disciplines such as Nursing, Physical Education, Biology, Accounting, and a few others resulting in a broad spectrum of backgrounds and levels of prior biology knowledge.

Table 1: Number of Students(n) participating in ECP Classes and Experiment

Semester	**Experiment**	**Female**	**Male**	**Other**	**Total**
Fall, 2022	Heart Rate Experiment	74	7	1	82
Spring, 2023		77	5	0	82
Fall 2023		72	13	0	85

Data Collection and Assessments

Students utilized a mobile application to measure heart rate fluctuations following various physical activities. By engaging in this practical experiment, they gained insights into cardiovascular physiology and the impact of exercise on heart rate. This pedagogy was implemented in biology courses. This involved the use of hands-on activities and experiments in the classroom, as well as the use of digital resources (Azumio - Instant Heart Rate App) to complement the traditional lecture-based instruction of the course. The students were shown in class how to use the Azumio App to correctly measure their heart rate. It was explained to them the reason for the difference in results observed in each set (especially after performing a 5-minute exercise) which included 6 heart rate measurements. Students were later given the assignment to work on 5 more sets of this experiment and were taught how to analyze and interpret the data collected - this data would be later used by them to write a laboratory report. The experimental group of students was exposed to an experiential learning approach for three semesters. The curriculum design incorporated real-world scenarios, laboratory work, and interactive experiences to enhance their understanding of biological concepts.

Pre- and post-surveys were given to the undergraduates to assess student engagement. These surveys captured 'students' perceptions of their learning experiences, motivation, and interest in the subject matter. Additionally, we observed their active participation during experiential learning sessions.

1.1 Pre-Survey: A survey was administered to students enrolled in a university biology course to measure their motivation level before the experiment-centric pedagogy intervention. This survey asks students to rate their level of motivation and interest on a 1-7 Likert scale and include questions about their attitudes towards biology courses and their experiences with experiment-centric pedagogy.

1.2 Post-Survey: After the experiment-centric pedagogy intervention, a second survey was administered to students who participated during the implementation. This survey was identical to the pre-survey and was also used to measure student motivation and interest after the intervention.

Understanding of Core Concepts

Pre- and post-signature assessments were used to gauge 'students' comprehension of the 'experiment's core concepts. These assessments focused on key learning objectives related to heart rate regulation and data interpretation.

Performance

At the end of the semester, students were required to write and submit a report of the experiment and analyze the data collected from each set of experiments. Project assignments allowed students to apply their knowledge in practical scenarios. These assignments required critical thinking, problem-solving, and effective communication. Grading rubrics were used to evaluate their performance objectively after they were made available to the students.

Discussion And Results

Research Question I: How does the implementation of hands-on learning approaches, specifically centered around hands-on activities and experiments, impact student engagement in biology education?

The study observed and measured 'students' engagement in class using various indicators, such as participation, attention, curiosity, and feedback. The data analysis revealed that there was a high level of engagement across all the classes where ECP was implemented and compared to the non-ECP group where the traditional lecture-based pedagogy was used. The results demonstrate that hands-on learning approaches foster student engagement in biology education and create a more interactive and stimulating learning environment as students involved found this method intriguing and compelled to learn while having fun or exploring.

Results shown in Figures 2-4 show that students in the non-ECP group engaged in some assigned activities, which in this case was taking surveys and assessments. Participants in the ECP class were better engaged in the experiential learning activities than those in the non-ECP group, who showed little engagement. 'Students' presentations, such as showcasing experiment results, show significant value in the ECP class. By sharing their findings, students reinforce their understanding and contribute to the collective learning experience. Additionally, these presentations foster critical thinking, communication skills, and scientific inquiry, which are essential for future scientists and researchers.

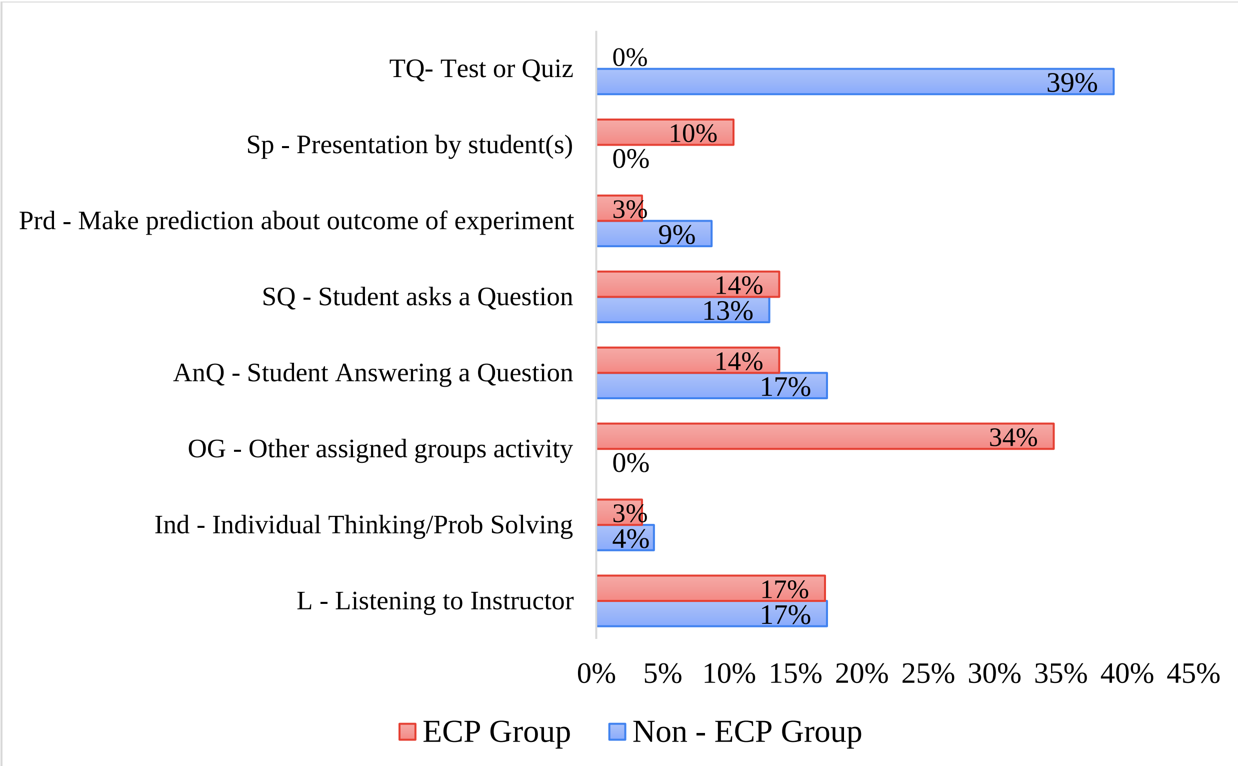

Figure 2: Student Engagement in Fall 2022

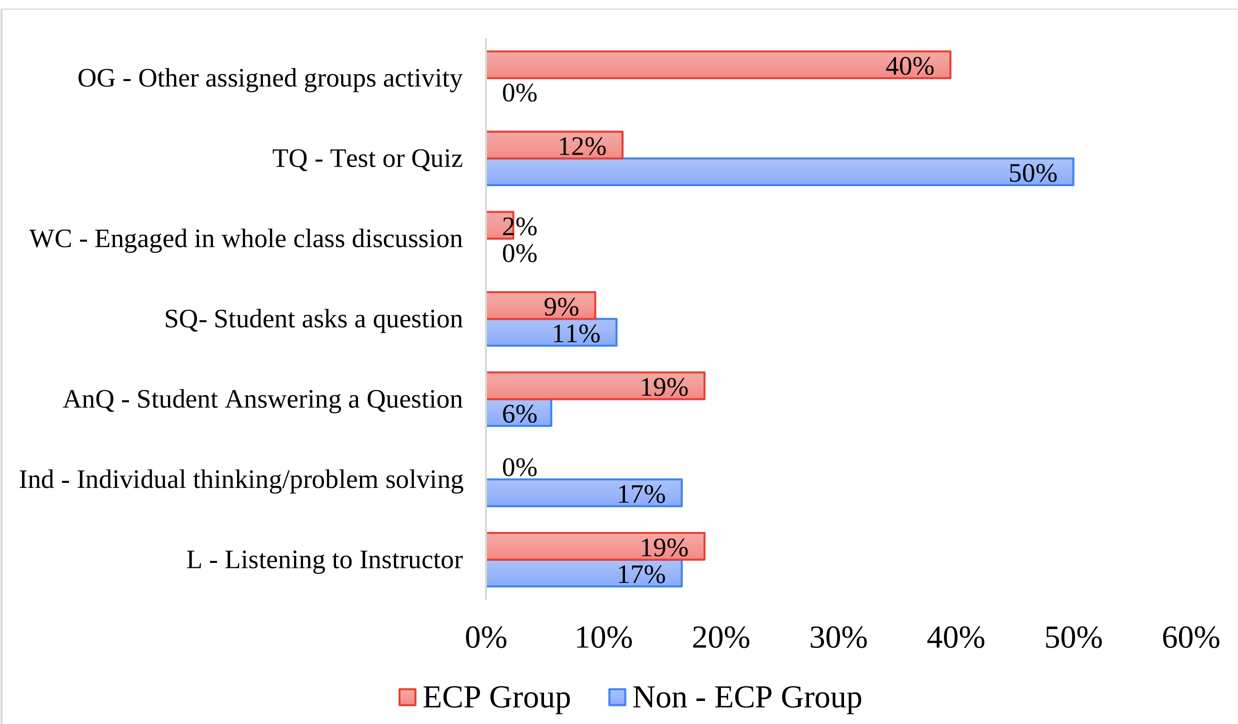

Figure 3: Student Engagement in Spring 2023

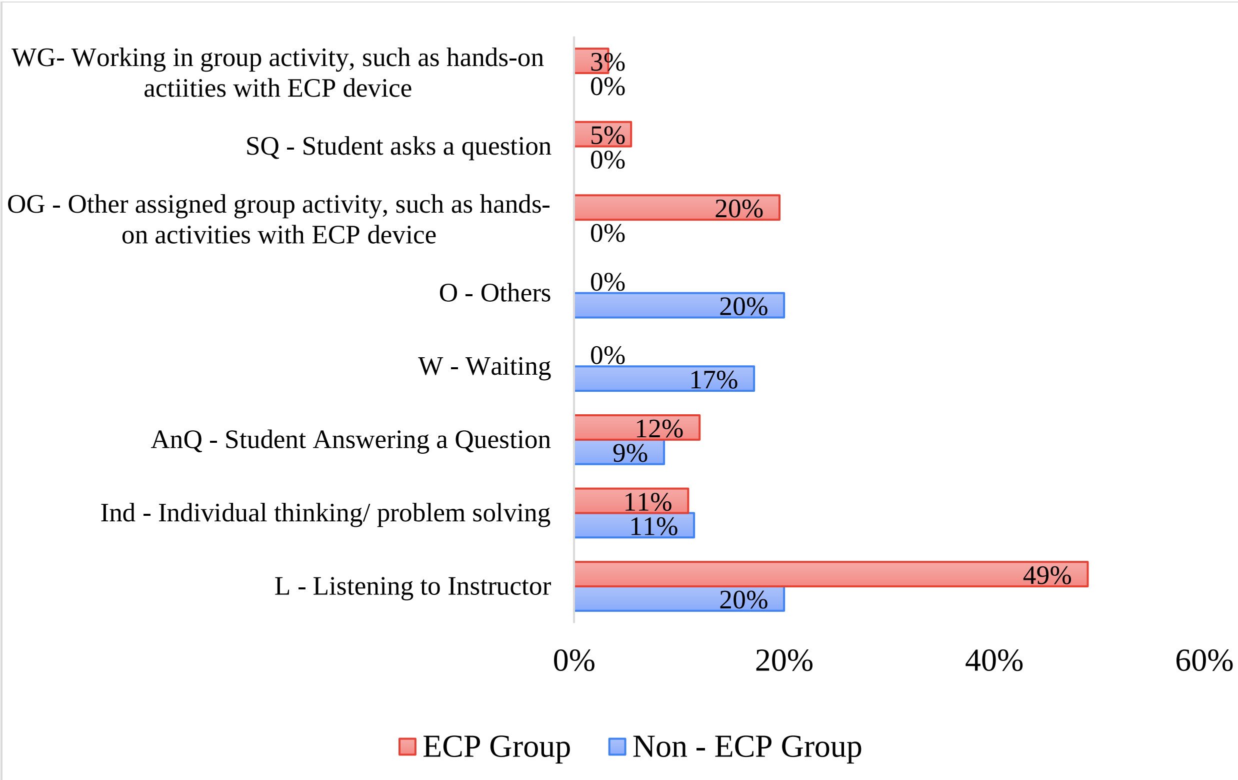

Figure 4: Student Engagement in Fall 2023

The findings by Sarah et al [38] explored math-biology task values among life science majors. Students reported high utility value and interest in using mathematics to understand biology task values. Importantly, these task values predicted 'students' likelihood of taking advanced quantitative biology courses. Another study by Odum et al., [39] explored student engagement in two active learning classrooms with different seating arrangements. The result of this study shows that the use of hands-on building activities and flexible seating arrangements contributed to enhanced student engagement in the current study.

Research question II: What are the effects of hands-on learning on student academic achievement, particularly in understanding core concepts and practical application in biology courses?

The present study also examined the effects of experiential learning on student academic achievement in biology courses, focusing on the understanding of core concepts and practical application of the cardiovascular system. The study adopted a pre and post-test design to measure the changes in student knowledge and comprehension before and after our intervention.

Tables 2 and 3 show the results of the ECP and non-ECP groups for Spring 2023 and Fall 2023, respectively.

Table 2: Spring 2023 Percentage score for ECP and Non-ECP classes

	Non-ECP Group		ECP – Group 1		ECP – Group 2	
	Pre Lab	Post Lab	Pre Lab	Post Lab	Pre Lab	Post Lab
Average score	65.2	71.3	62.7	84.2	62.5	78
Minimum score	40	40	40	50	50	50
Maximum score	90	100	80	100	80	100

Table 3: Fall 2023 Percentage score for ECP and Non-ECP classes.

	Non-ECP Group		ECP - Group 1		ECP- Group 2	
	Pre Lab	Post Lab	Pre Lab	Post Lab	Pre Lab	Post Lab
Average Score	63.8	68.3	57.9	71.4	59.1	74.5
Minimum score	50	50	30	50	40	50
Maximum score	90	90	80	100	70	100

The post-signature assessment revealed that undergraduates who participated in hands-on activities demonstrated significantly higher engagement, performance, and deeper understanding of the cardiovascular system than those in the control group (non-ECP). Moreover, the students expressed positive attitudes towards the experiment-centric teaching mode and reported that they learned more and had more fun than in the traditional lecture-based mode. This finding aligns with previous research highlighting the benefits of active learning strategies in promoting student engagement and learning.

In their study, Aji et al [38] incorporated active learning in higher education and showed how it positively affects student learning and achievement. Evidence from their study shows that active learning methods enhance interaction, reasoning skills, retention same as what results from our research shows in the case of how hands-on learning has enhanced student learning outcomes and motivation amongst participants in biology classes used in the present study.

Research question III: How does hands-on learning contribute to enhancing critical thinking skills, problem-solving abilities, and motivation among biology students potentially improving their overall learning outcomes in STEM?

During our hands-on sessions, we closely observed student behavior and interactions. When students were challenged with questions during the experiments, they demonstrated rapid critical thinking. The dynamic nature of hands-on activities encouraged them to analyze situations, evaluate evidence, and make informed decisions. This aligns with the work of Kolb [39], who emphasized that experiential learning fosters critical thinking by engaging leaners in active problem-solving processes. The students also demonstrated problem-solving abilities when encountering minor difficulties or errors during the hands-on experiments. Rather than becoming discouraged, they actively sought solutions. The iterative nature of hands-on learning allowed students to refine their problem-solving strategies and adapt to unexpected situations, like in the case of their apps having technical issues. They also learned to develop resilience during the whole process that took them a couple of weeks.

Furthermore, we noticed that the students expressed genuine interest in the subject. Their curiosity was evident during class discussions, where they asked insightful questions and explored beyond the prescribed curriculum. This intrinsic motivation is consistent with self-determination theory [40], which posits that autonomy, competence and relatedness drive intrinsic motivation.

The results of the Motivated Strategies for Learning Questionnaire (MSLQ) administered to the participants are shown in Table 4 and 5 respectively.

Table 4: Comparison of the Pre-Post Test Score of Students

	Post-test (N=251)		Pre-Test (N=251)	
Items	Mean	S. D	Mean	S. D
Intrinsic goal orientation (IGO)	5.14	1.33	4.90	1.58
Extrinsic goal Orientation (EGO)	6.15	1.38	5.10	1.99
Task Value (TV)	5.83	1.31	5.16	1.82
Expectancy component (EC)	5.84	1.46	5.17	1.88
Test anxiety (TA)	5.09	1.69	4.84	1.83
Critical Thinking (CT)	4.68	1.42	4.68	1.55
Metacognition (MC)	5.25	1.26	4.80	1.61
Peer-learning and collaboration (PLC)	4.00	1.71	4.26	1.62
Interest epistemic curiosity (IEC)	3.11	0.65	2.94	0.81
Deprivation epistemic curiosity (DEC)	2.46	0.67	2.58	0.78

Table 5: T-test for Motivation Constructs

Items	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Intrinsic goal orientation (IGO)	0.23	1.87	1.98	250	0.05
Extrinsic goal Orientation (EGO)	1.05	2.50	6.66	250	0.00
Task Value (TV)	0.67	2.13	4.95	250	0.00
Expectancy component (EC)	0.67	2.20	4.83	250	0.00
Test anxiety (TA)	0.25	2.17	1.82	250	0.07
Critical Thinking (CT)	0.00	1.94	0.01	250	0.99
Metacognition (MC)	0.45	1.87	3.81	250	0.00
Peer-learning and collaboration (PLC)	-0.26	1.89	-2.22	250	0.03
Interest epistemic curiosity (IEC)	0.17	0.87	3.06	250	0.00
Deprivation epistemic curiosity (DEC)	-0.13	0.79	-2.60	250	0.01

Tables 4 and 5 show that both intrinsic and extrinsic motivation levels increased. Students were internally motivated by their genuine interest in the subject (Intrinsic Goal Orientation, IGO). Simultaneously, they recognized the external benefits of mastering biology concepts (Extrinsic Goal Orientation, EGO). Task Value (TV) also increased, representing the perceived importance of the learning tasks. Students understood the relevance of hands-on learning to their academic and future career success.

The findings corroborate several studies that have emphasized the transformative potential of hands-on learning in STEM education. For instance, a study by Freeman et al. [41] found that students in classes with traditional lecturing were 1.5 times more likely to fail than students in classes with active learning. Prince [42] emphasized that active learning strategies, such as hands-on experiences, promote higher-order thinking skills and intellectual engagement.

Conclusion

The current study investigated the effects of an experiment-centric approach to teaching the cardiovascular system in a biology class. The results showed marked improvements in student engagement and performance. However, it is important to note that these improvements were not uniform across all students. Some students benefited more from the hands-on approach than others, suggesting that individual differences play a role in the effectiveness of this pedagogical approach. The study found that the students who participated in our experimental group showed higher levels of motivation, engagement, and conceptual understanding than those in the non-ECP group. The experimental group of students actively participated in the class activities, such as making hypotheses, asking and answering questions, and applying critical thinking skills. Our findings suggest that our approach can be a useful pedagogical strategy for enhancing student learning outcomes in other classes where student interest and attention are low.

The study contributes to the discourse on the transformative potential of hands-on learning in biology education. It suggests that this approach can create a more engaging and meaningful learning experience for biology students. Leading to improved academic achievement and persistence. The current study adhered to ethical guidelines to ensure the integrity of the study findings. In addition, it was ensured that the research design was inclusive and did not disadvantage any student based on their background or learning style. Further research is recommended to explore the generalizability and sustainability of the study approach in different contexts and subjects.

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APPENDIX

1. Students are Doing	
L	Listening to instructor/taking notes, etc.
Ind	Individual thinking/problem solving. Only mark when an instructor explicitly asks students to think about a clicker question or another question/problem on their own.
CG	Discuss clicker question in groups of 2 or more students
WG	Working in groups on worksheet activity
OG	Other assigned group activity, such as responding to instructor question
AnQ	Student answering a question posed by the instructor with rest of class listening
SQ	Student asks question
WC	Engaged in whole class discussion by offering explanations, opinion, judgment, etc. to whole class, often facilitated by instructor
Prd	Making a prediction about the outcome of demo or experiment
SP	Presentation by student(s)
TQ	Test or quiz
W	Waiting (instructor late, working on fixing AV problems, instructor otherwise occupied, etc.)
O	Other – explain in comments

2. Instructor is Doing	
Lec	Lecturing (presenting content, deriving mathematical results, presenting a problem solution, etc.)
RtW	Real-time writing on board, doc. projector, etc. (often checked off along with Lec)
FUp	Follow-up/feedback on clicker question or activity to entire class
PQ	Posing non-clicker question to students (non-rhetorical)
CQ	Asking a clicker question (mark the entire time the instructor is using a clicker question, not just when first asked)
AnQ	Listening to and answering student questions with entire class listening
MG	Moving through class guiding ongoing student work during active learning task
1o1	One-on-one extended discussion with one or a few individuals, not paying attention to the rest of the class (can be along with MG or AnQ)
D/V	Showing or conducting a demo, experiment, simulation, video, or animation
Adm	Administration (assign homework, return tests, etc.)
W	Waiting when there is an opportunity for an instructor to be interacting with or observing/listening to student or group activities and the instructor is not doing so
O	Other – explain in comments

Figure 5: COPUS Constructs [36]

SAMPLE SURVEY QUESTIONS

Construct	**Sample Question**
Intrinsic Goal Orientation (IGO)	In a class like this, I prefer course material that really challenges me so I can learn new things.
Extrinsic Goal Orientation (EGO)	Getting a good grade in this class is the most satisfying thing for me right now.
Task Value	It is important for me to learn the course material in this class.
Expectancy Component	I believe I will receive an excellent grade in this class.
Test Anxiety	I have an uneasy, upset feeling when I take an exam.
Critical Thinking	I often find myself questioning things I hear or read in this course.
Metacognition	When I become confused about something I'm reading for this class; I go back and try to figure it out.
Peer Learning and Collaboration (PLC)	When studying for this course, I often try to explain the material to a classmate or a friend
Interest Epistemic Curiosity Scale (IECs)	I enjoy exploring new ideas
Deprivation Epistemic Curiosity Scale (DECs)	Difficult conceptual problems can keep me awake all night thinking about solutions