

## Improving Student Engagement & Comprehension: A Symbiosis Between Art & Science in a Non-Major Undergraduate Ecology Course

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### ABSTRACT

Student engagement in higher education settings has been a pressing yet unanswered issue. Active learning strategies and teaching methodologies have proven to be effective means of improving student outcomes, retention, and engagement. Furthermore, previous research highlights the benefits of emotional engagement through art-based learning approaches (Díaz-Obregón et al., 2019; Staples et al., 2019). This exploratory pilot study examines the impact of art-based active learning on undergraduate students in a non-major ecology course. Data were gathered from an ecology course provided to undergraduate students at an international branch campus in South Korea. Data sources included student survey responses, semi-structured focus group interviews, and written reflection assignments. Findings reveal that art-based active learning can enhance students' holistic engagement, motivation, and emotional connection to the subject matter, which, in turn, promoted a more immersive and transformative learning experience. Further implications and future research directions are discussed.

**Key Words:** art-based learning, undergraduate science education, student engagement, student emotions.

### ○ Introduction

Over the past few decades, student engagement has been recognized as a key predictor of student success, persistence, and retention in higher education (Carini et al., 2006; Cassidy & Eachus, 2000; Kim et al., 2023; Maguire et al., 2017). In particular, low student engagement in STEM (science, technology, engineering, and mathematics) comes with high costs for both individuals and society (Perry, 2022). Although general education and introductory biology courses are essential to both individual and social development (Kyle, 2020; Perry, 2022), students taking mandatory general education courses outside their major commonly display low engagement, motivation, and interest with limited prior knowledge of the subject or field (Fryer et al., 2014; Ulbig, 2010).

Active learning (AL), which focuses on student-centered, constructivist teaching and learning methods, has been shown to improve student engagement, motivation, higher-order and

critical thinking, and achievement in biology education (e.g., Burrows, 2003; Hopper, 2016; Michael, 2006; Zireva, 2022). Additionally, previous research underscores the significant role of emotions in learning and student success (e.g., Beard et al., 2014; Imordino-Yang & Damasio, 2007; Kim et al., 2023; Kurth & Pihkala, 2022). However, the impact of engaging emotions in undergraduate environmental education remains underexplored. Art can effectively engage emotions and enhance cognitive functioning and learning. Incorporating art into environmental education is known to improve student engagement, comprehension, and problem-solving abilities (Bentz, 2020; Staples et al., 2019). Thus, this pilot study explores the effectiveness of integrating art-based active learning (ABAL) in an undergraduate ecology course for non-majors, specifically focusing on the following questions: (a) How do students perceive the role of ABAL in their engagement with the subject of biology? and (b) How does ABAL affect student emotions and actions toward environmental issues?

### ○ Literature Review

#### **Art-Based Active Learning & Student Engagement**

Previous research has consistently shown that the quality of teaching practices and the college environment significantly influence students' learning outcomes, success in various aspects of life, and overall well-being (e.g., Astin, 1984; Forest, 2007; Maguire et al., 2017; Zepke & Leach, 2010). Student engagement has been defined as "students' active involvement and participation in school-based activities" (Boekaerts, 2016, p. 81). McCormick et al. (2013) stated that the term "engagement" has become ubiquitous in higher education discussions, encompassing various goals and practices, such as academic, behavioral, cognitive, and affective elements. Medrick (2013) and Forest (2007) argued that instructors should also engage students' emotions, physicality, and spirituality in their teaching. Despite its popularity, there is a significant gap between the commitment colleges and universities claim to have for student engagement and the reality in classrooms (Harper & Quaye, 2014).

Likewise, research increasingly focuses on the integral role emotion plays in student learning, decision-making, and social functioning (Beard et al., 2014; Imordino-Yang & Damasio, 2007). Indeed, as student engagement is viewed as multidimensional, research across multiple fields has highlighted the interconnections among all areas of human development (academic, cognitive, linguistic, social, and emotional), advocating for a holistic engagement framework (Edwards et al., 2020; Jones & Kahn, 2017; Kim et al., 2023; Olszewska et al., 2023). Notably, one emotional dimension that has received increasing research interest recently is “eco-anxiety”: anxiety arising from the ecological crisis (Coffey et al., 2021; Pihkala, 2020a). A global survey of young people found that over 80% were worried about climate change, and nearly half reported that their daily functioning was negatively impacted by these feelings (Hickman et al., 2021). Thus, eco-anxiety can be debilitating and can negatively impact learning as it amplifies stress and feelings of unease and impotence (Kurth & Pihkala, 2022). There is an additional concern that eco-anxiety may affect other psychological issues (Pihkala, 2020a). However, eco-anxiety can also galvanize people to take action and problem-solve (Pihkala, 2020b). Studies reported that the feelings of impotence and paralysis associated with eco-anxiety can be countered by fostering hope through ecologically oriented and art-based activities (Howard, 2022; Pihkala, 2020b).

Art has the ability to engage emotions, which play a pivotal role in cognitive functioning and, therefore, learning (Bentz, 2020; Imordino-Yang & Damasio, 2007). Furthermore, students’ critical thinking, creativity, and problem-solving skills improved when art or liberal arts education was integrated into STEM education (Bucciarelli & Drew, 2015; Díaz-Obregón et al., 2019; Staples et al., 2019; Zaher et al., 2023). Art is also a means of communication, connection, transformation, problem-solving, awareness-raising, and expression of learning (Bentz, 2020). Thus, art has the potential to improve engagement with and comprehension of science, particularly in environmental science, to transform students’ attitudes and actions. However, there has been limited focus on the impact of engaging emotions through ABAL to improve learning in undergraduate environmental education.

### **Theoretical Framework: Transformative Learning Theory**

Rooted in constructivist assumptions and inspired by humanism and critical social theories, transformative learning theory was proposed by Jack Mezirow (1991) to explain how adults learn, transform, and develop (Cranton & Taylor, 2012). Mezirow (2018) defines transformative learning as a process of revising problematic frames of references to make them more inclusive, discriminating, open, reflective, and capable of change. While transformative learning may manifest differently across contexts, scholars agree that the overarching goal is to develop more inclusive, discriminating, and permeable worldviews (Mezirow, 1991; Stuckey et al., 2013). Thus, the goal of Mezirow’s theory is deriving meaning from the experience of learning to guide one’s action from the new or revised interpretation of meaning (Mezirow, 1990).

Over the decades, transformative learning theory has been extended and critiqued from multiple perspectives. A few of these include the cognitive perspective, extra-rational perspective, and social critique perspective (Cranton, 2016). The cognitive or rational perspective emphasizes rationality, critical reflection, and ideal conditions for discourse. Learning is viewed as a process of constructing and appropriating new or revised interpretations of

one’s experiences, with a goal of greater personal autonomy and independence (Mezirow, 1991). The extra-rational perspective emphasizes the emotive, imaginal, spiritual, and arts-based facets of learning beyond rationality (Dirkx, 1998; Lawrence, 2012; Tisdell, 2000). This perspective highlights personal, intuitive, and imaginative ways of knowing as a means to develop the “self” separated from but integrated with the collective humanity (Boyd & Myers, 1988). Lastly, the social critique perspective emphasizes ideological critique, unveiling oppression and social action in the context of transformative learning (Brookfield, 2012; Freire, 2018). This perspective views people as subjects who are constantly reflecting, acting on the transformation of their world, and developing critical consciousness.

Despite critiques that Mezirow’s theory insufficiently incorporates social action and critical theory (Habermas, 1971), transformative learning continues to evolve as scholars highlight additional dimensions of adult learning. Clark and Wilson (1991) argue that all human learning is context-dependent, building on Mezirow’s (1985) point that adults recognize the significance of context as they mature. Considering the diverse perspectives and the emphasis on transformation, this study employed transformative learning theory as an apt theoretical lens to analyze students’ critical reflection, interpretations of their experiences, and the process of art-based learning to engage with emotions and shift perspectives.

## **○ Research Methods**

### **Research Context**

The study was conducted at an international branch campus of a state university in the United States located in a city in South Korea (Korea hereafter). According to the Cross-Border Education Research Team (C-BERT, 2023), U.S.-based institutions operate 84 international campuses. While the model, structure, and offering of the program may vary depending on the host country’s policies, Wilkins and Rumbley (2018) define international branch campuses as “an entity that is owned, at least in part, by a specific foreign higher education institution, which has some degree of responsibility for the overall strategy and quality assurance” including “programming and/or credentials that bear the name of the foreign institution” (p. 14). The current research site offers associate, undergraduate, and graduate programs across eight departments. The research was conducted in an ecology course entitled Ecology and Environmental Problems, taught by the second author during Spring 2023. A total of 28 students were enrolled in this course, all of whom were in the business or design departments. This was a mandatory course for students to fulfill their general education requirements.

In previous semesters, a general biology course had been offered and engagement among the students had been low. With a background in humanities and a career interest in either design or business, the students reported not seeing value in a science course. The second author noticed students’ reluctance, even resentment, and clear disinterest in the subject. Thus, this environmental science course was designed to increase the accessibility of science for humanities students by leveraging their background in arts and creativity. As we launched this pilot study, we also aimed to foster students’ sense of agency through inquiry-based assignments that would encourage them to see themselves as integral to both their education and their environment. What follows is a discussion of the results of the first “pilot” iteration of this course.

The course incorporated six art-based homework assignments that facilitated student-centered reflection and critical thinking (see Appendix A, provided as Supplemental Material with the online version of this article). Many of the assignments were designed so students could choose their own topics. The instructor gave guidance on the science while the students brought their own artistic preferences to the assignment. In this way, the students' education was more self-directed and more relevant to their lives. Table 1 provides descriptions of each homework assignment. Appendix A illustrates summaries of each assignment description and instructions given to students. The assignments involved three steps: a planning stage for a small percentage of the grade, the assignment outlined in Table 1 for the majority of the grade, and a reflection stage for an additional percentage point. We hope these results will be useful to others aiming to make science accessible to students from artistic, non-science backgrounds.

### Data Collection & Analysis

Data were collected during the spring semester of 2023 (February–June). All participants in the study provided informed consent before participating. They were informed about the study's purpose, procedures, potential risks, and benefits, with the freedom to withdraw at any time. Ethical approval for this study was obtained from the university's Institutional Review Board (IRB ID#2022-00449). Surveys were distributed online via Qualtrics on a voluntary basis: once in April, after students completed three major ABAL homework assignments (Homework 1–3), and again in

June, after students completed the latter three homework assignments (Homework 4–6). Additionally, students were offered the option to attend a focus group interview about the course. Finally, the students' homework reflections were analyzed/reviewed for insight into their perspectives on the assignments and their learning. Quantitative data consisted of survey questions asking students to rate (on a 1–7 Likert scale) the impact of each homework assignment on their engagement and understanding. Analysis of differences in rating among assignments was conducted by Friedman test. Students' homework scores were also collected; however, since assignments were graded for completion, this is not an integral part of the discussion. Table 2 outlines the data collection timeline in conjunction with the art-based homework assignment descriptions.

Qualitative data comprised (a) the answers to open-ended questions in the survey asking students to explain their rating, (b) focus group interviews, and (c) students' reflection papers ( $n = 75$ ). Voluntary focus group interviews were conducted after each round of the survey. Each interview was recorded and transcribed, totaling 41 pages of interview transcripts, before analysis. Sample questions for the semi-structured focus group interviews included the following prompts: (a) Tell me about your experience with the course. (b) How did your knowledge about ecological and environmental issues change over time? (c) How were the homework assignments challenging and beneficial to you? (d) What role did the art-based active learning strategies play in your learning? All participants' written reflections (1–2 pages long) after completing each homework assignment, totaling 85 pages of reflections, were also analyzed. A few guiding questions were provided to students so they could write their reflection paper. Besides the topic-specific questions, students received these sample reflection guiding questions: (a) How did the homework assignment help you understand the topic? (b) Having received your grade, what will you do differently for the next assignment? (c) How difficult was this assignment and why? (d) In what way has this assignment altered your perspective on science?

Qualitative data were analyzed using the steps of qualitative thematic analysis outlined by Maguire and Delahunty (2017).

**Table 1.** ABAL Homework Assignments

Homework Assignment	Description
Homework 1: Documentary comparison	Watch and compare two assigned documentaries about environmental issues with stylistic differences (artistic vs. lecture-based documentaries).
Homework 2: Comparing reliable sources	Investigate opposing viewpoints on a controversial environmental issue/topic of students' choice and evaluate the information to identify reliable and unreliable sources.
Homework 3: Biomimicry	Find inspiration in nature to create a new design/invention/object or to improve an existing item.
Homework 4: Solving an environmental problem on campus	Identify a problem involving a threat to biodiversity and suggest a solution that can be implemented on campus.
Homework 5: SciArt project	Communicate to the public the importance of an environmental issue of your choosing.
Homework 6: Educational video	Create a video that will educate your classmates on an environmental topic.

**Table 2.** Data Collection Timeline

Homework Assignment	Survey	Focus Group Interview
Homework 1: Documentary comparison	Survey 1 ( $n = 17$ ) distributed April 25, 2023	Focus group interviews ( $n = 2$ ) on May 16, 2023
Homework 2: Comparing reliable sources		
Homework 3: Biomimicry		
Homework 4: Solving an environmental problem on campus Homework 5: SciArt project Homework 6: Educational video	Survey 2 ( $n = 14$ ) distributed May 30, 2023	Focus group interviews ( $n = 3$ ) on June 12–13, 2023

A theory-based thematic analysis was employed using perspectives and conceptual categories of transformative learning theory suggested by Cranton (2016) and Stuckey et al. (2013). The first two phases of Maguire and Delahunt's (2017) thematic analysis method suggest becoming familiar with data and generating initial theory-based codes. Reflecting cognitive, extra-rational, and social critique perspectives (Cranton, 2016), Stuckey et al. (2013) developed an outcome-and-process assessment model of transformative learning comprising 17 categories. Qualitative data were initially coded using this model. Next, the researchers searched, reviewed, and defined themes as coded data emerged. Initial themes included (a) Art-based imagination, (b) Learning through experience, (c) Critical reflection and critique, and (d) Action-oriented change. Applying Braun and Clarke's (2016) thematic analysis framework, the researchers analyzed qualitative data to identify patterns and themes and wrote up the emerging themes. Through comprehensive coding cycles and discussions, several categories and themes emerged, which are presented in the following sections.

## ○ Quantitative Data Results

The online surveys were distributed to all students enrolled in the course ( $n = 28$ ) during the spring of 2023. Seventeen responses were received from the first survey and 14 from the second (distributed in April and May, respectively). When asked how the homework assignment influenced their learning or understanding, students overall rated the assignment positively. The lowest mean rating was 5.3/7 for homework assignment 4, and the highest was 5.9/7 for assignment 6, with an overall mean of 5.6/7. There were no significant differences in rating among assignments (Friedman test,  $p = 0.958$ ). Mean performance scores for the six assignments ranged from 71.3% for assignment 3 to 98.7% for assignment 6 and these differences were not significant (Friedman test,  $p = 0.192$ ).

## ○ Qualitative Data Findings

Four major themes emerged from the qualitative data analysis. Consistent with the quantitative data, the qualitative data showed positive student feedback. Two of these themes highlighted engagement with the learning process, while two other themes provided more insights into the learning outcomes. The following four themes are discussed further: (a) learning through experience, (b) learning through emotional triggers and investment, (c) shifts in perspective, and (d) empowered for social action.

### **Learning Through Experience**

The ABAL assignments grounded in inquiry-based learning had an impact on students' overall educational experiences. Inquiry-based learning refers to a process of discovering new causal relations or information, with the learner formulating hypotheses and testing them through experiments or observations (Pedaste et al., 2012). Choosing a topic of interest and conducting in-depth research or creating a tangible product as a result of the assignment engaged students in the process of learning.

For example, Homework 2 required students to identify credible sources, assess their reliability, and locate information from opposing viewpoints.

The topic I chose was "Does the use of paper straws help reduce environmental pollution?" This assignment helped me to do source finding and made me realize how persuasive credible sources and figures can be. The topic I chose had clear arguments and supporting evidence for both the pro and con sides, so many of the claims confused me... By finding credible sources for each claim, I was able to research and understand the topic more deeply and learn more about a new topic. (P13, HW2 Reflection)

By conducting in-depth research into the sources of information and the groups that sponsor certain organizations that share information online, students learned about the complex sociopolitical interrelationships surrounding environmental issues. Investigating the credibility of online resources also developed students' transferable skills in searching for and analyzing evidence-based research (P3, Focus group Interview1\_0516, p. 3).

The opportunity to invent something in Homework 3 also inspired students to learn and research the function and features of a biological being. This process allowed students to learn how to apply scientific principles to solving real-life problems (P3, Survey 1) and appreciate "how the environment still has so much to offer" (P24, HW3 Reflection). Similarly, trying to solve an environmental problem on campus in Homework 4 motivated students to conduct thorough research and problematize something close to their everyday lives.

While researching the problem...I learned why the existence of stray cats can be harmful to biodiversity. As there are lots of stray cats on our campus, this issue came to mind. Therefore, it can be said that this assignment helped me to connect my experience on campus with the problem that harms biodiversity. (P1, HW4 Reflection)

As illustrated in one of the student reflections, the experience of problem-posing, inquiring, investigating, evaluating, creating, and problem-solving motivated them to seek knowledge. The inquiry-based, "learning by doing" course structure became a transformative learning experience, enabling students to rethink not only what it means to learn in college but also their role in addressing environmental issues.

### **Learning Through Emotional Triggers & Investment**

Student emotions play a critical role in their motivation, creativity, social integration, engagement, and empowerment (Kim et al., 2023; Maguire et al., 2017; White, 2013). Analysis of the data revealed that, beyond rational or extra-rational aspects of learning through the incorporation of art, it triggered students' emotional responses or led to emotional investment. Students expressed in many of the assignments that their emotional investment in certain environmental issues has motivated them to learn and conduct thorough research. They also described the joy and fun of using artistic expression to complete the assignments.

In particular, Homework 3, the biomimicry project, required students' creativity and elicited positive emotions and reactions, as it resonated well with students in the design major.

It was more fun because it required creativity, and the fact that I could make something myself made it more interesting. (P10, Survey 1)

P10 mentioned the joy of creating and making something of their own. Similarly, in the focus group interview, P19 described the

fun of creating something inspired by nature, which also facilitated further learning.

P19: For Homework 3, because I'm a fashion design major, an idea that could be combined with it came to me, so I had a lot of fun doing it...When I design, I usually like to get inspiration from natural objects. Normally, I would have just looked at the appearance, color, or things like that of natural objects, but during this assignment, I learned that there is a lot to explore in terms of functionality as well. (Focus group interview2\_0612, pp. 5-6)

Art integration in the curriculum intends to enhance students' comprehension of academic subjects by using multimodal approaches and engaging them in a creative process (Marshall, 2014). As reflected in students' positive emotions, the creative expression and process increased their engagement and facilitated their comprehension of science.

The freedom to choose their own topic or environmental issue also allowed students to select a topic they cared about and invest more time in completing the assignments.

[I noticed] I don't randomly choose topics for the assignments without giving them much thought, which I normally would have done in high school science class. I rather choose topics that I am genuinely interested in. [I was] able to immerse in the assignments and enjoy doing them. (P23, HW4 Reflection)

Furthermore, the artistic aspects of certain assignments or materials elicited emotions such as care and empathy, thereby contributing to student engagement.

P18: Just watching things on YouTube; things are getting serious these days. Environmental issues, global warming itself, things that we directly feel like the weather...I've been aware of these environmental issues...now, when I watch things on YouTube, I see a lot about biodiversity loss and things like that...Honestly, we don't usually watch documentary movies in our lifetime...When I actually watched it, it was really interesting, and I started to pay more attention...The homework assignment was really good because it allowed me to think more deeply about these issues. (Focus group interview 1\_0516, p. 3)

One of the documentaries students had to watch, *Seaspiracy* (2021) by Ali Tabrizi, provides a vivid yet artistically constructed picture of the oceans impacted by the fishing industry. Compared with other documentary films students encounter, the delivery of this documentary engendered stronger emotions, alerting students to the environmental impacts of overfishing. Beyond the joy of art integration in learning, students reported a wide range of emotions that triggered, motivated, and inspired them to engage further with the course material and global environmental issues.

### **Shift in Perspective**

Many students also described how the assignments shifted their perspectives on environmental problems and their worldviews. Reflection is one of the key concepts in transformative learning theory pertaining to content, process, and premise reflection (Cranton, 2016; Mezirow, 1991). Content reflection refers to an examination of the content or problem, while process reflection involves problem-solving strategies. Premise reflection involves questioning the

problem itself. The ABAL course assignments allowed students to undertake various reflective and critical thinking practices, allowing them to broaden or change their perspectives.

Homework 2, for example, was an opportunity for students to reflect on course content, which also broadened their perspectives regarding the credibility of online sources. Students described how the assignment encouraged them to engage in a particular environmental problem. P24 explained how overhearing other students' conversations about the "myth of climate change" became a motivation to conduct research on the topic.

I was motivated to do the homework. It was the initial interest that motivated me and affected the work. I was listening to a joking conversation between students regarding whether climate change is actually happening and whether it is simply propaganda. This led me to actually have an interest in the assignment, which increased my productivity. (P24, HW 2 Reflection)

Similar to P24, students discussed how forcing themselves to research both opposing viewpoints "changed [their] complete outlook on the topic" (P16, HW2 Reflection), "improved [their] critical thinking skills" (P13, HW2 Reflection), and changed their habits from "clicking on the first article that pops on internet search" (P10, Survey1).

Furthermore, students began to interrogate their understanding of environmental problems and the science subject through premise reflection. Students noticed the role they could play in making changes and understood the interrelationships between science and their own lives.

This assignment gave me a better understanding of how environmental science is not external to daily life in the sense that it is not limited to something outside and incomprehensible. My view of science changed to something more inclusive as I researched how it can affect people with the adaptations. (P18, HW3 Reflection)

Instead of viewing science as a subject to study and memorize, assignments requiring in-depth research and creativity, such as the biomimicry assignment, taught them the close relationship between environmental science and human lives. These shifts in perspectives, facilitated by ABAL strategies, transformed students' beliefs, values, and attitudes toward environmental science

### **Empowered for Social Action**

The in-depth knowledge students gained through all assignments and increased awareness empowered many students to consider taking action toward making changes. Habermas (1971) stated that emancipatory knowledge, referring to the knowledge and habit of questioning, is a goal of adult education. Such emancipatory knowledge is built through the process of critically questioning ourselves and the social systems, which leads to planning a course of action and reintegrating into society with new perspectives (Cranton, 2016; Mezirow, 1991). As students reflected on their new perspectives, they planned the course of action to change their current surroundings, which in turn, alleviated eco-anxiety.

One student explained that in-depth knowledge of science and ecology helped them step out of their comfort zone and actively engage with the course content.

My knowledge of ecology, or any branch of science, is not the greatest. I think I am making some progress in

expanding my understanding of things outside of my usual comfort zone. I had always felt pressured when it came to studying science because it felt very overwhelming.... Learning about subjects like ecosystems, biodiversity, and pollution in depth was very interesting and fun since the environment is something I actually care about. (P23, HW4 Reflection)

The opportunities to dive deep into researching environmental problems and closely interact with the course content motivated students to learn science and helped them realize how science exists close to their lives.

Many students also described the impact of the homework assignments, particularly on their habits, skills, and perceptions.

P12: Something new I learned is...the city plans are publicly available online. So, it shows how much of the area will be created as a park in the future. I was curious about that while I was working on Homework 4, so I looked it up... And I was thinking about solving the plastic waste problem, and suddenly got curious and searched because I remember hearing that Korea's per capita plastic consumption rate is the first or second around the world. (Focus group interview 2\_0612, p.12)

In the focus group interview, P12 discussed how they were inspired to seek more information after learning and researching environmental problems. These changes in habits and awareness also influenced students' future plans and behaviors.

This assignment helped me think about how I act in my everyday life. I realized that I have been buying clothes I do not really need, and this can cause more microfibers to end up in the ocean. I also did not pay attention to...what materials they are made of. Now, I understand that I need to take responsibility for the environment. (P10, HW6 Reflection)

While concluding the last homework assignment, P10 wrote in the reflection that the assignment helped them rethink their everyday habits and gain awareness of the broader societal and environmental impact of their actions. Many students also mentioned changes in their understanding of environmental problems and in the information available online (Survey 1, P10; P16, HW2 Reflection), which empowered them as knowledgeable advocates for the environment. They also described changes in their motivation to raise more awareness of environmental problems, followed by various skills they developed throughout this course (P2, HW6 Reflection).

Overall, students expressed feeling informed, engaged, and empowered by developing or improving evidence-based knowledge, creativity, critical thinking, and problem-solving skills. The ABAL course setting allowed students to be more involved and autonomously engaged in the course content, which, in turn, transformed their learning process and future actions as competent and knowledgeable advocates for sustainability. Furthermore, ABAL assignments helped mitigate eco-anxiety as students felt more empowered to counter negative emotions caused by climate change.

## ○ Discussion

This exploratory pilot study examined the impact of ABAL on student engagement in an undergraduate ecology course. Quantitative data from survey results and qualitative data from students' written survey responses, focus group interviews, and written reflections

shed light on several implications for non-major undergraduate science education.

First, ABAL enhanced students' holistic engagement. The findings in this study demonstrated that providing students with agency in their learning process was a crucial factor in engaging students as holistic and independent selves. Previous research highlighted the importance of self-directed and problem-based learning in STEM education as it allowed students to improve their knowledge, conceptual understanding, and interests (Sahin & Top, 2015; Tang et al., 2024). When students were allowed to choose their research topics, they demonstrated higher levels of engagement by pursuing knowledge beyond the assignment requirements purely out of interest. This sense of agency and autonomy in learning fostered intrinsic motivation and a deeper connection to the subject matter. Furthermore, integrating creativity into the coursework through ABAL, such as the biomimicry homework assignment, played a pivotal role in increasing students' interest and engagement. The creative tasks encouraged students to think outside traditional boundaries, thus making the learning experience more dynamic, enjoyable, and holistic. This also aligns with previous studies suggesting that creative freedom can promote student engagement and retention (Carini et al., 2006; Garrett, 2013).

Second, students' awareness and confidence in environmental science increased. Transformative learning theory stresses individual and social transformation through critical reflection and ideological critique (Brookfield, 2012; Cranton, 2016). By relating ecological principles to reflect on everyday life and on-campus issues, students were able to grasp larger environmental themes and societal structures more effectively. Exemplified by one student's attempt to investigate biodiversity loss through observation of the on-campus stray cat issue, practical applications of knowledge helped students solidify their understanding of macro-level biological concepts. Furthermore, this fostered greater awareness of environmental issues in students' everyday lives as students' level of confidence in the subject increased. While this study did not extensively explore the role of critical reflection in learning, it is worth noting that through this exploratory study, critical thinking and awareness have been identified as significantly impacting students' knowledge and enhancing self-efficacy (Ghanizadeh, 2017). Future research might benefit from examining the specific contributions of critical reflection and social critique activities within ABAL contexts.

Lastly, emotions emerged as a critical component in the overall educational experience, noticeably influencing student engagement, motivation, and empowerment. Transformative learning theory emphasizes emotive, imaginal, and art-based learning processes that allow learners to develop a real sense of self (Mezirow, 2018). Students were more engaged when they found assignments enjoyable, and emotional responses were frequently triggered by activities such as watching aesthetically designed documentaries. Previous research emphasized the benefits of positive emotions in the process of learning (e.g., Kim et al., 2023; Maguire et al., 2017; White, 2013). The findings indicated that beyond positive emotions, a wide range of emotional experiences facilitated students' motivation to learn global environmental issues and promoted in-depth learning of the subject matter. Moreover, the emotional engagement through ABAL led to a sense of empowerment among students. They felt informed and capable of making changes in their personal lives to contribute to broader society, such as environmental conservation efforts or reducing microfiber pollution. This finding is consistent with the work of Pihkala (2020a) and Howard

(2022), who have noted the importance of emotional engagement in fostering environmental action.

This study demonstrated that ABAL is an effective pedagogical approach to enhancing student engagement in an undergraduate ecology course for non-majors. Leveraging students' background and experience in arts and creativity, the course positioned students as co-creator of knowledge, as students applied their scientific knowledge in creative practices. By fostering student agency, encouraging multiple forms of creativity, and leveraging emotional engagement, ABAL offered a more immersive and transformative learning experience. The integration of scientific and artistic ways of thinking not only expanded students' cognitive repertoires but also supported deeper meaning-making by inviting them to interpret ecological concepts through expressive modalities. Furthermore, ABAL can be leveraged to reduce feelings of eco-anxiety and promote feelings of empowerment. This aspect of ABAL will likely take on increasing importance in education as communities face increasingly frequent and severe natural disasters. Students developed heightened ecological awareness, reported feeling empowered as a change agent, and some even expressed plans to take action to solve ecological problems.

## ○ Considerations & Limitations

While this study's findings contribute to the discussion and understanding of ABAL in undergraduate science education, the limitations of this research should be noted. It is important to acknowledge that academic performance is influenced by multiple factors, including engagement. While our study did not focus on academic grades as a primary outcome to evaluate students' engagement, we recognize that lenient grading practices in the course could limit the generalizability of our findings. Additionally, written assignments, while valuable, may not fully capture the breadth of student learning and motivation. Participants were also limited to students enrolled in a single course at a single institution in Korea, and sample sizes were small. As undergraduate general education requirements and non-major science education may differ across varying national and institutional contexts, larger-scale research is necessary. This course was also run only once, so it was not possible to compare the efficacy of this design with a control group, as in a traditional experimental study. However, we hope this course inspires others to try this approach, especially in situations when students have an artistic background and are reluctant to study science.

## ○ Conclusion

Incorporating ABAL activities into a non-major ecology course positively influenced student engagement with science and the environment. ABAL helped students recognize connections between course content and their everyday lives, thereby enhancing their engagement through autonomous learning. The ABAL approach not only helped students engage more meaningfully with the course materials but also bolstered their confidence to tackle concepts outside their comfort zone. This ultimately shifted students' perspectives on the relevance of science in their personal and professional lives. The findings of this study indicated that ABAL effectively mobilizes emotions and creativity to support the learning process and outcomes. Assignments that encouraged creativity fostered positive emotions, which, in turn, improved students' engagement

with the course materials. Additionally, certain assignments elicited emotional responses, increasing students' awareness and interest in environmental issues. This emotional engagement often led to a sense of empowerment, with students feeling motivated to take action on real-world environmental concerns. Enhancing student engagement, motivation, and enjoyment in general education science courses can nurture informed and empowered citizens. Such individuals will be better equipped to make a positive, transformative impact on society and the environment. Overall, ABAL proved to be a valuable pedagogical approach to achieving the ultimate educational goals in undergraduate science education.

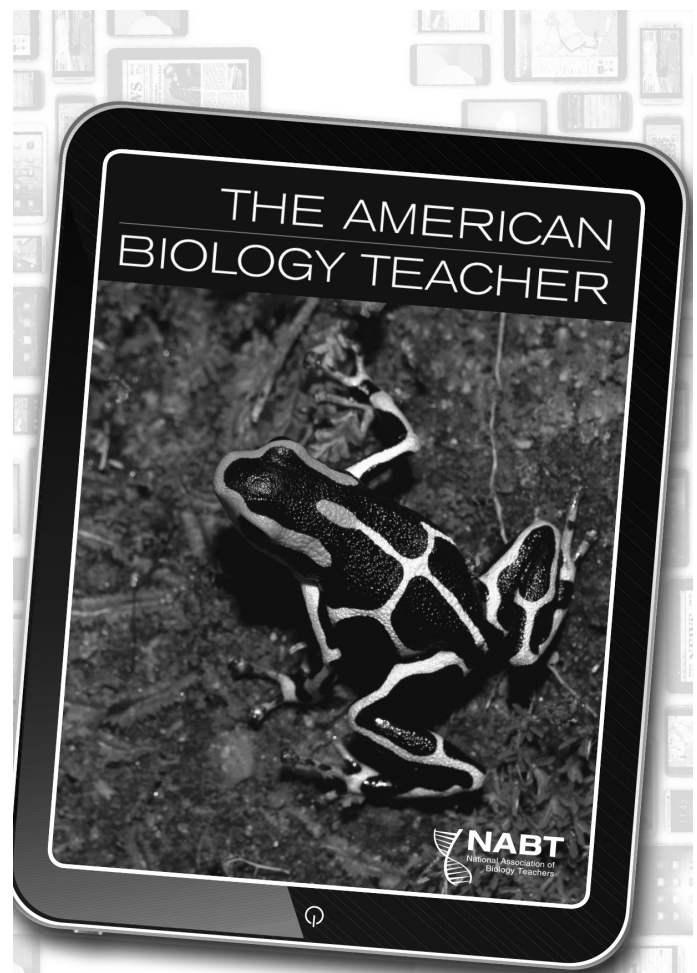
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