

**Developing Environmental Literacy Through Problem-Based Learning in One
Secondary School in Astana**

Ayash Yelamanova

Submitted in partial fulfillment of the requirements for the degree of
Master of Science
in
Educational Leadership

Nazarbayev University Graduate School of Education

April, 2026

Word count: 18,938

Author Agreement

By signing and submitting this license, I Ayash Yelamanova grant to Nazarbayev University (NU) the non-exclusive right to reproduce, convert (as defined below), and/or distribute my submission (including the abstract) worldwide in print and electronic format and in any medium, including but not limited to audio or video.

I agree that NU may, without changing the content, convert the submission to any medium or format for the purpose of preservation. I also agree that NU may keep more than one copy of this submission for purposes of security, back-up and preservation.

I confirm that the submission is my original work, and that I have the right to grant the rights contained in this license. I also confirm that my submission does not, to the best of my knowledge, infringe upon anyone's copyright.

If the submission contains material for which I do not hold copyright, I confirm that I have obtained the unrestricted permission of the copyright owner to grant NU the rights required by this license, and that such third-party owned material is clearly identified and acknowledged within the text or content of the submission.

IF THE SUBMISSION IS BASED UPON WORK THAT HAS BEEN SPONSORED OR SUPPORTED BY AN AGENCY OR ORGANIZATION OTHER THAN NU, I CONFIRM THAT I HAVE FULFILLED ANY RIGHT OF REVIEW OR OTHER OBLIGATIONS REQUIRED BY SUCH CONTRACT OR AGREEMENT.

NU will clearly identify my name(s) as the author(s) or owner(s) of the submission, and will not make any alteration, other than as allowed by this license, to your submission.

I hereby accept the terms of the above Author Agreement.

Author's signature:

Date: 01.04.2026



Declaration

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been submitted for the award of any other course or degree at NU or any other educational institution, except where due acknowledgment is made in the thesis. This thesis is the result of my own independent work, except where otherwise stated, and the views expressed here are my own.

Author's signature:

Date: 01.04.2026

A handwritten signature in black ink, consisting of stylized, cursive letters that appear to be 'J' and 'Z' or similar characters.

Ethical Approval



Ayash Yelamanova <ayash.yelamanova@nu.edu.kz>

Re: 1116_Ayash Yelamanova_03092025 Full board review_Aproved

4 messages

resethics resethics <resethics@nu.edu.kz>
To: Ayash Yelamanova <ayash.yelamanova@nu.edu.kz>
Cc: Kairat Kurakbayev <kkurakbayev@nu.edu.kz>

Wed, Oct 1, 2025 at 10:37 AM

Dear Ayash,

On 01/10/2025, following a full board review of your application, subsequent revisions, and supporting documents, the Nazarbayev University Institutional Research Ethics Committee (NU-IREC) approved your submission, 1116/03092025, titled "Developing Environmental Literacy Through Problem -Based Learning in One Secondary School in Astana".

Please note that this approval is valid until **30/09/2026**. After this date, the protocol will automatically expire unless an extension is requested and approved in advance.

This approval is based on the information provided in your submitted documents. Any deviations from the approved protocol or the occurrence of an adverse/unanticipated event must be reported to NU-IREC immediately.

Principal Investigator Responsibilities:

1. Submit a Signed Hard Copy of the Application

A signed hard copy of the approved application must be submitted within three weeks of the approval date^{*}. Failure to submit the documents within this period will result in the automatic suspension of the project by NU-IREC.

2. Request an Extension (if needed):

If data collection needs to continue beyond the approval expiry date, please submit the "Appendix F: Request for Continuing IREC Approval" 4 to 6 weeks prior to expiration.

3. Request Amendments (if needed):

For any changes to the approved protocol, complete the "Appendix G: IREC Protocol Amendment Form."

4. Report Adverse/Unanticipated Events:

If such events occur, they must be reported using the "Appendix H: Adverse/Unanticipated Event Reporting Form."

5. Maintain CITI Training Compliance:

Ensure that all research team members have valid CITI training certifications throughout the study period. Updated certificates must be submitted before the approval expiration date.

Forms and Resources:

All required forms are available at: <https://orci.nu.edu.kz/irec>

Please retain this email as official documentation of NU-IREC approval for your study.

^{*}Bring your signed application/amendment/extension form to Room C4/650 within three weeks of approval.

Should you have any questions or require assistance, do not hesitate to contact the NU IREC office.

Kind regards,
Dilara

CITI Training Certificate



Completion Date 29-May-2025
Expiration Date 29-May-2028
Record ID 69810136

This is to certify that:

Ayash Yelamanova

Has completed the following Citi Program course:

Not valid for renewal of
certification through CME.

Social & Behavioral Research - Basic/Refresher
(Curriculum Group)
Social & Behavioral Research - Basic/Refresher
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Nazarbayev University

CITI
Collaborative Institutional Training Initiative

101 NE 3rd Avenue, Suite 320
Fort Lauderdale, FL 33301 US
www.citiprogram.org

Generated on 29-May-2025. Verify at www.citiprogram.org/verify/?w0ae7bb33-a128-43f0-b22f-4e805bcc1350-69810136

Acknowledgments

I would like to express my sincere gratitude to all faculty members of the Graduate School of Education for their continuous support, guidance, and commitment to academic excellence throughout my studies. Their dedication has significantly contributed to my professional and personal development.

I am especially grateful to my supervisor, Kairat Kurakbayev, for his invaluable guidance, insightful feedback, and encouragement during the completion of this thesis. His support and expertise have been instrumental in shaping this research.

I would also like to extend my sincere appreciation to Anita Jayachandran for her support in academic English, which greatly contributed to the clarity and quality of this thesis.

I would also like to thank my parents for their unwavering love, support, and belief in me. Their encouragement has always been a source of strength and motivation.

Finally, I am thankful to my friends for their support, encouragement, and companionship, which made this journey more meaningful and enjoyable.

Abstract

Developing Environmental Literacy Through Problem-Based Learning in One Secondary School in Astana

Environmental literacy is essential for fostering sustainable behaviors and addressing ecological challenges, yet traditional teaching methods in many Kazakhstani schools often limit the development of its multidimensional components. This quasi-experimental study investigated the effects of a six-week Problem-Based Learning (PBL) intervention, integrated into the Cambridge Lower Secondary Science curriculum, on seventh-grade students' environmental literacy in one private secondary school in Astana, Kazakhstan. Using a pretest-posttest design with a control group, the study compared a PBL treatment group ($n=25$) with a Cambridge curriculum instruction group ($n=22$). Environmental literacy was measured with the validated Environmental Literacy Instrument for Adolescents (ELI-A; Szczytko et al., 2019), assessing four components: ecological knowledge, environmental hope, cognitive skills, and responsible environmental behavior.

Results revealed selective improvements rather than broad gains across all dimensions. Paired-samples t -tests showed a statistically significant increase in responsible environmental behavior in the PBL group ($p = .002$, Cohen's $d = 0.69$). Mixed ANOVA indicated significant main effects of time for environmental knowledge and responsible behavior across both groups, but no significant Time $\times$ Group interaction effects. ANCOVA confirmed that differences in post-test total environmental literacy scores were largely attributable to pre-test variations rather than the intervention. Correlation analysis in the PBL group identified a moderate positive relationship between environmental knowledge and cognitive skills ($r = 0.566$, $p = .003$), with no other significant inter-component associations.

These findings suggest that embedding PBL within an existing student-centered curriculum can modestly promote environmentally responsible behavior in a short timeframe, while

comprehensive development of environmental literacy may require longer, more sustained interventions. The study provides rare empirical evidence on student-centered pedagogies for environmental education in a post-Soviet Central Asian context and offers practical implications for teachers, school leaders, and policymakers seeking to align classroom practices with Kazakhstan's national sustainability goals.

Keywords: environmental literacy, problem-based learning, environmental education, sustainable development, quasi-experimental study, secondary education, Kazakhstan, Cambridge curriculum

Аңдатпа

Экологиялық сауаттылық тұрақты мінез-құлықты қалыптастыру және экологиялық мәселелерді шешу үшін маңызды болып табылады. Дегенмен, Қазақстанның көптеген мектептерінде дәстүрлі оқыту әдістері оның көп өлшемді компоненттерін дамытуды шектейді. Бұл квазиэксперименттік зерттеу Астанадағы бір жеке орта мектептегі жетінші сынып оқушыларының экологиялық сауаттылығына Cambridge Lower Secondary Science оқу бағдарламасына енгізілген алты апталық Проблемалық оқыту (PBL) араласуының әсерін зерттеді. Претест-посттест дизайнымен бақылау тобы бар зерттеуде PBL эксперименттік тобы ($n=25$) Cambridge оқу бағдарламасы бойынша оқыту тобымен ($n=22$) салыстырылды. Экологиялық сауаттылық Szczytko et al. (2019) әзірлеген жасөспірімдерге арналған экологиялық сауаттылық құралы (ELI-A) арқылы өлшенді. Бұл құрал төрт компонентті бағалады: экологиялық білім, экологиялық үміт, когнитивтік дағдылар және экологиялық жауапты мінез-құлық.

Нәтижелер барлық өлшемдер бойынша кең ауқымды өсім емес, іріктеп жақсаруды көрсетті. Жұпталған t-тест PBL тобында экологиялық жауапты мінез-құлықтың статистикалық тұрғыдан маңызды өсуін көрсетті ($p = .002$, Cohen's $d = 0.69$). Mixed ANOVA екі топта да экологиялық білім мен жауапты мінез-құлық бойынша уақыттың негізгі әсерін көрсетті, бірақ ешқандай компонент бойынша Time $\times$ Group өзара әрекеттесу әсері статистикалық маңызды болмады. ANCOVA пост-тест жалпы экологиялық сауаттылық ұпайларындағы айырмашылықтар негізінен пре-тест айырмашылықтарымен түсіндірілетінін растады. PBL тобындағы корреляциялық талдау экологиялық білім мен когнитивтік дағдылар арасында орташа оң байланысты анықтады ($r = 0.566$, $p = .003$), басқа компоненттер арасында маңызды байланыс байқалмады.

Бұл нәтижелер бар студент-орталықтандырылған оқу бағдарламасына PBL енгізу қысқа мерзімде экологиялық жауапты мінез-құлықты қалыптастыруға қарапайым үлес қосатынын көрсетеді. Ал экологиялық сауаттылықтың толық көп өлшемді дамуы ұзағырақ және тұрақты араласуды қажет етуі мүмкін. Зерттеу посткеңестік Орталық Азия контекстінде экологиялық білім беру үшін студент-орталықтандырылған педагогикалық әдістер туралы сирек эмпирикалық дәлелдер ұсынады және мұғалімдерге, мектеп басшыларына, саясаткерлерге Қазақстанның ұлттық тұрақты даму мақсаттарымен сыныптық тәжірибені үйлестіру үшін практикалық ұсыныстар береді.

Түйін сөздер: экологиялық сауаттылық, проблемалық оқыту, экологиялық білім беру, тұрақты даму, квазиэксперименттік зерттеу, орта білім, Қазақстан, Cambridge оқу бағдарламасы

Аннотация

Экологическая грамотность играет ключевую роль в формировании устойчивого поведения и решении экологических проблем. Однако в большинстве казахстанских школ традиционные методы обучения часто ограничивают развитие её многомерных компонентов. Данное квазиэкспериментальное исследование изучило влияние шести недельного вмешательства на основе проблемно-ориентированного обучения (PBL), интегрированного в учебную программу Cambridge Lower Secondary Science, на экологическую грамотность учащихся седьмых классов одной частной средней школы в Астане, Казахстан.

В исследовании с использованием претест-посттест дизайна с контрольной группой сравнивалась экспериментальная группа, занимавшаяся по методу PBL ($n=25$), и контрольная группа, обучавшаяся по стандартной программе Cambridge ($n=22$).

Экологическая грамотность измерялась с помощью валидизированного инструмента Environmental Literacy Instrument for Adolescents (ELI-A; Szczytko et al., 2019), оценивающего четыре компонента: экологические знания, экологическую надежду (надежду на решение экологических проблем), когнитивные навыки и экологически ответственное поведение.

Результаты показали избирательное улучшение, а не всесторонний рост по всем измерениям. Парный t -тест выявил статистически значимое повышение экологически ответственного поведения в группе PBL ($p = .002$, Cohen's $d = 0.69$). Смешанный ANOVA показал значимый основной эффект времени для экологических знаний и ответственного поведения в обеих группах, однако значимых взаимодействий «время $\times$ группа» по ни одному из компонентов выявлено не было. ANCOVA подтвердила, что различия в итоговых показателях общей экологической грамотности в основном объясняются исходными различиями на претесте, а не самим вмешательством.

Корреляционный анализ в группе PBL выявил умеренную положительную связь между экологическими знаниями и когнитивными навыками ($r = 0,566$, $p = .003$); значимых связей между другими компонентами обнаружено не было.

Полученные результаты свидетельствуют о том, что внедрение проблемно-ориентированного обучения в уже существующую ученико-ориентированную программу может в короткие сроки способствовать modestному развитию экологически ответственного поведения. В то же время для всестороннего развития экологической грамотности, по-видимому, требуются более длительные и интенсивные вмешательства. Исследование предоставляет редкие эмпирические данные о применении ученико-ориентированных педагогических подходов в экологическом образовании в постсоветском центральноазиатском контексте и предлагает практические рекомендации для учителей, руководителей школ и разработчиков образовательной политики по приведению школьной практики в соответствие с национальными целями устойчивого развития Казахстана.

Ключевые слова: экологическая грамотность, проблемно-ориентированное обучение, экологическое образование, устойчивое развитие, квазиэкспериментальное исследование, среднее образование, Казахстан, учебная программа Cambridge

Table of Contents

Author Agreement.....	ii
Declaration.....	iii
Ethical Approval	iv
CITI Training Certificate.....	v
Acknowledgments.....	vi
Abstract	vii
Андатпа.....	ix
Аннотация	xi
Chapter 1: Introduction	1
1. 1 Background Information.....	2
1.2 Learner-Centered Pedagogy and Development of Students’ Environmental Literacy ...	5
1.3 Problem Statement	5
1.4 Research Purpose	7
1.5 Research Questions	7
1.6 Variables	9
1.6.1 Independent Variables	9
1.6.2 Dependent Variables.....	9
1.7 Significance of the Study.....	10
1.8 Summary.....	11
1.9 Outline of the Thesis	11
Chapter 2: Literature Review.....	13
2.1 Conceptual Clarification: Environmental Education	13
2.1.1 <i>The Historical Roots of Environmental Education</i>	13
2.1.2 Environmental Education in 21 st century.....	15
2.2 Environmental Literacy	18
2.2.1 <i>Conceptualizing Environmental Literacy</i>	18
2.2.2 <i>Components of Environmental Literacy</i>	19
2.2.2.1 <i>Knowledge</i>	21
2.2.2.2 <i>Dispositions</i>	21
2.2.2.3 <i>Competencies</i>	22
2.2.2.4 <i>Behavior</i>	22
2.3 PBL as a Pedagogical Approach	23
2.3.1 <i>Conceptualizing PBL</i>	23
2.3.2 <i>Advantages and Disadvantages of PBL</i>	24

2.3.2.1 <i>Advantages of PBL</i>	25
2.3.2.2 <i>Disadvantages of PBL</i>	28
2.3.3 PBL and Environmental Literacy	29
2.4 Theoretical Framework.....	31
2.5 Summary	33
Chapter 3: Methodology.....	35
3.1 Research Design	35
3.2 Sampling Strategies	36
3.3 Data Collection Instruments	38
Part 1: Ecological Knowledge	39
Part 2: Environmental Hope	39
Part 3: Cognitive Skills.....	40
Part 4: Behavior	40
Part 5: Demographics	40
3.4 Data Analysis Procedures	41
3.5 Intervention	43
3.6 Ethical Considerations.....	44
3.7 Summary	46
Chapter 4: Findings.....	47
4.1 Effects of the PBL Intervention on Environmental Literacy	48
4.1.1 <i>Total Environmental Literacy Scores</i>	48
4.1.2 <i>The Effects of the PBL Intervention on Environmental Literacy Components Scores</i>	49
4.1.2.1 <i>Knowledge</i>	49
4.1.2.2 <i>Hope</i>	50
4.1.2.3 <i>Cognitive Skills</i>	51
4.1.2.4 <i>Behavior</i>	52
4.2 Within-Group Changes in Environmental Literacy Scores: Cambridge vs. PBL.....	53
4.2.1 <i>Cambridge Curriculum Instruction Group</i>	54
4.2.2 <i>PBL Group</i>	55
4.3 Relationships among Post-Test Environmental Literacy Components	56
4.4 Summary	58
Chapter 5: Discussion	59
5.1 Effects of the PBL Intervention on Environmental Literacy	60
5.1.1 <i>Environmental Knowledge</i>	61

5.1.2 <i>Environmental Hope</i>	62
5.1.3 <i>Cognitive Skills</i>	63
5.1.4 <i>Behavior</i>	64
5.2 Relationships Among Environmental Literacy Components	65
Chapter 6: Conclusion	67
6.1 Summary of the Study	67
6.2 Strengths of the Study	68
6.3 Limitations of the Study	68
6.4 Implications for Research, Practice, and Policy	69
6.6 Directions for Future Research	70
6.7 Personal Reflection	71
References	72
Appendix A: AI Declaration Form	88
Appendix B: Intervention Plan	89
Appendix C: Consent Letters	97
Appendix D: Recruitment Emails	101
Appendix E: Data Collection Instruments	103

List of Table

Table 1 ANCOVA Results for Total Environmental Literacy Scores	48
Table 2 Homogeneity of Variance Test for Total Environmental Literacy	49
Table 3 Mixed ANOVA Results of Pre-Test and Post-Test Knowledge Scores of the PBL and Control Groups	50
Table 4 Mixed ANOVA Results of Pre-Test and Post-Test Hope Scores of the PBL and Control Groups	51
Table 5 Mixed ANOVA Results of Pre-Test and Post-Test Cognitive Skills Scores of the PBL and Control Groups	52
Table 6 Mixed ANOVA Results of Pre-Test and Post-Test Behavior Scores of the PBL and Control Groups	53
Table 7 Paired-Samples t-Test Results for Pre-Test and Post-Test Environmental Literacy Scores in the Cambridge Instruction Group	54
Table 8 Paired-Samples t-Test Results for Pre-Test and Post-Test Environmental Literacy Scores in the PBL Group.....	55
Table 9 Correlations among Post-Test Environmental Literacy Components in the PBL Group	57

List of Figures

Figure 1 <i>Theoretical Framework of the Study</i>	32
--	----

Chapter 1: Introduction

“But man is part of nature, and his war against nature is inevitably war against himself” wrote Rachel Carson in *Silent Spring* (1962). These powerful words from the pioneer of the modern environmental movement show an urgent need to rethink how people act with nature. More than sixty years after the *Silent Spring* started a global awareness of environmental problems, the challenges for our planet became even bigger. The rapid increase in environmental degradation poses a serious threat for long-term survival of human civilization (Awewomom, 2024; Ukaogo, 2020). Anthropogenic activities, like deforestation, industrialization, and resource extraction, continue to harm natural systems, including biodiversity, climate regulation, water resources, soil quality, and ecosystems in a broader sense. These damages not only put plant and animal life in danger, but also threaten human health, economic stability, and social structures (Cofone et al., 2024; Zheng et al., 2021).

In response to these growing concerns, promoting environmental literacy has been recognized as one of the key educational goals for sustainable development in the 21st century (UNESCO, 2017). Environmental education (EE), aligned with the Sustainable Development Goals (SDGs), demands modern teaching methods that enhance environmental literacy through enriched, issue-based, and problem-oriented content. Such content serves as a chance for transformative EE by fostering student-centered and inquiry-based pedagogies (UNESCO MGIEP, 2017). One promising pedagogical approach is Problem-Based Learning (PBL), which is formally defined as "an instructional method in which students learn through facilitated problem solving" (Hmelo-Silver, 2004, p. 235), where learners identify knowledge gaps, engage in self-directed research, and reflect on their processes to build flexible knowledge and skills. Another key definition positions PBL as "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (Savery, 2015, p. 20), emphasizing its role in bridging theoretical concepts with real-world applications.

This quantitative quasi-experimental study examines the impact of PBL on development of environmental literacy among students in one secondary school in Astana, Kazakhstan.

This chapter introduces the study by discussing background information on EE in Kazakhstan and PBL. It then explores how learner-centered pedagogies, such as PBL, contribute to developing students' environmental literacy. Next, it presents the problem statement, research purpose, and research questions that guide the study. After that, it highlights the expected contributions of the study and defines key variables, such as environmental literacy and PBL. Finally, the chapter provides an outline of the thesis, offering a preview of the following sections.

1. 1 Background Information

Kazakhstan is the largest landlocked country in the world, similar in size to Western Europe or Argentina. It is rich with vast natural resources, ranking among the most mineral-rich countries globally and placing within the top 15 nations for proven oil reserves (World Bank, 2019). As the world's leading producer of uranium and a major exporter of coal, gold, manganese, titanium, zinc, and lead, Kazakhstan's economy has been heavily shaped by extractive industries (International Trade Administration, 2022).

External trade, primarily in hydrocarbons and metals, has driven much of the country's economic growth, accounting for an average of 79.3% of GDP between 1991 and 2022 (OECD, 2023; World Bank, 2024, as cited in OECD, 2024). However, decades of resource overexploitation and weak environmental regulations have led to severe ecological imbalances, including air, water, and soil pollution, along with biodiversity loss. These challenges have been exacerbated in industrial centers such as Pavlodar, Almaty, and Shymkent, which consistently record high levels of gas pollutants (Bočková et al., 2023). In fact, Kazakhstan ranked 23rd globally for PM_{2.5} pollution levels in 2021 (IQAir, 2022, as cited in Mukhtarov et al., 2023).

In response to these challenges, Kazakhstan has become an active participant in international environmental initiatives. It ratified the Paris Agreement in November 2016, committing to enhance

environmental literacy and prepare specialists capable of addressing ecological issues at both societal and governmental levels (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2023). To support this commitment, Kazakhstan develops a comprehensive legal and policy framework focusing on sustainability. The Environmental Code of the Republic of Kazakhstan (2007) established mechanisms to regulate human-environment interactions and promotes sustainable development. Likewise, the National Development Plan until 2029 (Decree No. 611, 2024) aims to enhance economic competitiveness while integrating environmental protection into national policy. The Strategy for Achieving Carbon Neutrality by 2060 (Decree No. 121, 2023) further shows Kazakhstan's long-term vision for transition to a low-carbon economy. During the UN Summit on SDGs, Kazakhstan reaffirmed its intention to embed sustainability into national development and educational strategies (UNESCO, 2025). This environmental commitment is reflected in two key education policy initiatives: The Concept of Development of Higher Education and Science (2023–2029) and The Concept of Development of Preschool, Secondary, Technical, and Vocational Education (2023–2029). These documents emphasize the importance of sustainability at all levels of education by focusing on teacher training, accessibility, and development of critical thinking skills necessary to address environmental challenges (UNESCO, 2025). In parallel, several national initiatives have been launched to raise environmental awareness among youth. The ECOMUSEUM project, for example, provided educational materials such as *Climate is Changing – It Concerns Me!* (*Климат меняется — это касается меня!*) for students in Grades 7–9, focusing on climate change and sustainability. Likewise, the Green Schools initiative, launched by the Bulat Utemuratov Foundation in 2021, established greenhouses in 40 schools across Kazakhstan, offering students hands-on experiences in sustainability, biology, and scientific inquiry (UNESCO, 2025). Kazakhstan's State Compulsory Educational Standards (SCES), outlined in Order No. 604 (2018), highlights the country's growing commitment to EE. These standards integrate environmental topics into core subjects such as Natural Science (Grades 5–6), and Biology, Chemistry, and Physics (Grades 7–11) (Ministry of Education and Science of the Republic of Kazakhstan, 2018). Article 183 of

the Environmental Code reinforces this direction, and states “the system of continuous and comprehensive environmental education shall cover all levels of education” (p.142).

Kazakhstan’s policy framework emphasizes the institutionalization of environmental education as a cross-cutting priority within the national curriculum. “Environmental education shall be carried out in educational institutions through the implementation of specialized and interdisciplinary educational programs, as well as the integration of environmental aspects into existing disciplines” (The Law of the Republic of Kazakhstan, 2007, Section 7, Article 183).

Despite Kazakhstan’s commitment to promoting sustainability through education, its curriculum frameworks face implementation challenges. Although environmental topics are integrated into subjects like Natural Science and Biology, they rarely incorporate innovative, student-centered teaching strategies such as Problem-Based Learning (PBL). Defined as “an instructional method in which students learn through facilitated problem solving” (Hmelo-Silver, 2004, p. 235), PBL fosters critical thinking, collaboration, and self-directed learning by engaging students with real-world problems. However, educational practices in Kazakhstan often rely on traditional methods, such as note-taking and textbook-based assignments, which may not sufficiently promote deep understanding of ecological systems or sustainable resource management. This limitation is evident in national evaluations and international assessments. Research by the Ministry of Education and Science of the Republic of Kazakhstan, supported by Programme for International Student Assessment (PISA) data, indicates limited environmental literacy among students. In PISA 2018, Kazakhstan ranked 65th out of 74 countries in science, a subject encompassing environmental education, with few students classified as top performers capable of applying scientific knowledge autonomously and creatively in diverse contexts (OECD, 2019). Despite an improved ranking of 49th out of 81 countries in PISA 2022, these results underscore the need for interactive, context-driven pedagogies to enhance higher-order thinking and real-world engagement with sustainability (OECD, 2022). The reliance on traditional teaching methods and limited adoption of approaches like PBL highlight the need for innovative pedagogies to

strengthen environmental literacy. By addressing local issues such as air pollution and biodiversity loss, PBL can bridge the gap between theoretical knowledge and practical application, supporting Kazakhstan's sustainability goals and the global Sustainable Development Goals (SDGs).

1.2 Learner-Centered Pedagogy and Development of Students' Environmental Literacy

Globally, many school systems now adopt learner-centered pedagogies, such PBL, to enhance students' environmental literacy, defined as the knowledge, attitudes, skills, and behaviors needed for environmental stewardship (NAAEE, 2011). PBL is an instructional method where students learn through solving real-world, ill-structured problems in collaborative settings, fostering critical thinking and self-directed inquiry (Hmelo-Silver, 2004). This approach enables students to address complex issues like climate change, pollution, and biodiversity loss, aligning with the EE goal of cultivating action-oriented citizens, as outlined in the Tbilisi Declaration (UNESCO & UNEP, 1977). For example, in Hong Kong, pre-university geography students used PBL to explore global warming and human-environment conflicts, improving their critical thinking and environmental awareness through group-based problem analysis (Yeung, 2010). Similarly, in the United States, middle school students in Iowa applied PBL to study water pollution and climate change, producing policy-focused letters that enhanced their engagement and understanding of environmental science (Basche et al., 2016). In South Africa, pre-service geography teachers investigated water quality through PBL fieldwork, developing inquiry skills and a deeper grasp of ecological complexities (Raath & Golightly, 2017). In Ethiopia, secondary school teachers used PBL to teach deforestation and climate change, fostering student motivation despite challenges like large classes (Wahelo et al., 2025). These cases demonstrate the flexibility of PBL within EE, offering a basis for the suggested research to explore its use in Astana, and add proof regarding education that transforms environmental perspectives.

1.3 Problem Statement

Despite Kazakhstan's policy commitments to fostering environmental literacy through education, there remains a significant gap in empirical evidence regarding the effectiveness of innovative, student-

centered pedagogies such as PBL in enhancing secondary school students' environmental literacy. Traditional teaching methods still prevalent in many Kazakhstani schools may not sufficiently support the development of critical thinking, problem-solving skills, and environmentally responsible behaviors. This is supported by research indicating that traditional approaches are insufficient for comprehensive student development and show gaps in fostering higher-order thinking skills (Khassenova, 2025), while a discrepancy persists between policy expectations and classroom practices in developing critical thinking (Kassembekova, 2020). Additionally, critical thinking remains only modestly integrated into learning outcomes within teacher education programs (Kabysheva, 2025).

The participating school follows the Cambridge curriculum, which promotes active learning, scientific enquiry, and the development of practical skills alongside conceptual understanding. The curriculum aims to help students think scientifically, recognize the relevance of science to their lives, and acquire the knowledge and skills needed to make informed decisions about sustainability issues and the environmental challenges facing the world. This philosophy clearly aligns with the goals of environmental literacy (Cambridge International Education, n.d.).

However, despite the student-centered intentions of the Cambridge, its actual implementation in everyday classroom practice may vary. In this study, Cambridge curriculum instruction group (control group) primarily followed standard curriculum delivery, emphasizing structured lessons, textbook use, and teacher guidance. While effective for building foundational scientific knowledge, this approach provides limited opportunities for students to engage deeply with real-world environmental problems, collaborate extensively, and apply knowledge in authentic contexts.

In contrast, PBL offers a pedagogical approach that can fully realize and extend the Cambridge curriculum's intended goals by situating learning within authentic environmental challenges and promoting inquiry, collaboration, and problem-solving. Recent research has highlighted PBL's potential to foster positive science attitudes and enjoyment among middle school students, even in disadvantaged contexts (Seçgin & Sungur, 2020), and to enhance conceptual understanding and sustained interest

through socially relevant, student-centered projects (Ottenbreit-Leftwich et al., 2021). By focusing on locally relevant environmental issues, this study examines whether integrating PBL within the Cambridge Lower Secondary Science framework can significantly improve multiple dimensions of environmental literacy — ecological knowledge, environmental hope, cognitive skills, and environmentally responsible behavior.

1.4 Research Purpose

The purpose of this quasi-experimental study is to examine the influence of a PBL intervention on the environmental literacy levels of students in one private secondary school in Astana, Kazakhstan. In this study, environmental literacy is defined as the ability to demonstrate a broad understanding of environmental concepts, issues, and challenges, along with the attitudes, cognitive skills, and behaviors required to apply this knowledge in real-life environmental decision-making contexts (NAAEE, 2011; Hollweg et al., 2011).

By investigating how PBL affects students' environmental literacy levels (knowledge, hope, cognitive skills, and responsible behavior), the study aims to identify practical implications for improving the quality of environmental education in Kazakhstani schools. In addition, it explores the relationships among the four core components of environmental literacy following the PBL intervention.

Ultimately, this research seeks to determine the degree to which student-centered interventions like PBL can enhance environmental literacy and critical thinking while generating actionable evidence to guide future curriculum reforms and environmental education policies in Kazakhstan.

1.5 Research Questions

To address the research purpose within the context of a quasi-experimental design, the following research questions are developed to compare the treatment group receiving the PBL intervention with a control group. The following research questions are set to achieve the research purpose:

Research Question 1: To what extent does the PBL intervention influence students' environmental literacy (knowledge, hope, cognitive skills, and responsible behavior)? This research

question evaluates the differences in students' environmental literacy levels, which are measured through knowledge, hope, cognitive skills, and behaviors, before and after the implementation of the PBL intervention. It aims to assess the overall impact of PBL on students' ability to understand and apply environmental concepts, solve problems, and demonstrate responsible environmental behaviors.

Research Question 2: Is there a significant difference between students who experienced the PBL intervention and those who received Cambridge curriculum instruction in terms of post-test environmental literacy scores? This research question specifically examines whether the PBL group and the Cambridge curriculum instruction (control) group differ significantly in their overall environmental literacy levels after the intervention, as measured by the total score on the Environmental Literacy Instrument for Adolescents (ELI-A). It focuses on the post-test comparison between the two groups while considering any initial pre-test differences that may exist. By addressing this question, the study aims to determine the relative effectiveness of the PBL approach compared to content-based teaching methods in enhancing students' environmental literacy in the context of a Kazakhstani secondary school. This question complements Research Question 1 by isolating the between-group differences at the end of the intervention period.

Research Question 3: What is the relationship between students' environmental knowledge, hope, cognitive skills, and environmentally responsible behavior following the PBL intervention? This research question examines the strength and direction of relationships among the four core components of environmental literacy after students have participated in the PBL intervention. Specifically, it aims to determine whether students with higher levels of environmental knowledge and more positive environmental hope are also more likely to demonstrate stronger cognitive skills and behavioral intentions. The goal is to identify how these components are interconnected and whether knowledge and attitudes can predict environmentally responsible behavior in the context of PBL.

1.6 Variables

1.6.1 Independent Variables

Exposure to PBL – in this study, students were not engaged in the full cycle of PBL per se, but rather in a structured intervention that introduces them to its core features. PBL is defined as “an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem” (Savery, 2015, p. 20). Within the intervention, students were exposed to different PBL scenarios (e.g., working with authentic problems, collaborative inquiry, and guided solution development) adapted to the constraints of time and curriculum.

1.6.2 Dependent Variables

Environmental literacy – the capacity of an individual to make informed environmental decisions, both independently and collaboratively, based on knowledge of environmental issues, combined with a willingness to take action, engage in civic life, and contribute to the well-being of society and the planet through sustainable behavior (NAAEE, 2011). This concept encompasses a citizen who understands ecology, cares about the environment, has the skills to analyze complex issues, and is motivated to act (Hollweg et al., 2011). Environmental literacy is measured across four components:

Ecological knowledge – understanding of basic ecological principles and how they relate to real-world environmental issues.

Hope – a disposition reflecting optimism about the ability to address environmental problems, serving as a proxy for broader affective inclinations toward environmental responsibility.

Cognitive skills – abilities to identify environmental issues, analyze, investigate, and evaluate solutions, representing practical thinking and problem-solving competencies.

Behavior – visible actions individuals take that have a measurable impact on environmental quality, focusing on environmentally responsible behaviors (Szczytko et al., 2019).

1.7 Significance of the Study

This study holds both theoretical and practical importance for advancing environmental education (EE) in Kazakhstan and similar contexts, particularly within the broader global pursuit of sustainability. Theoretically, it contributes to the growing body of research on PBL as a pedagogical tool for developing environmental literacy. By examining the effects of a PBL intervention on private secondary school students in Astana, the study addresses a notable gap in the literature, where most empirical evidence on PBL and environmental literacy originates from Western or East Asian settings (e.g., Basche et al., 2016; Yeung, 2010). In contrast, there is limited research from post-Soviet Central Asia. The quasi-experimental design, which measured changes in ecological knowledge, environmental hope, cognitive skills, and responsible behavior before and after the intervention (Szczytko et al., 2019), provides valuable insights into the interconnections among these components, as explored in Research Questions 1, 2, and 3. These findings may refine existing models of environmental literacy by demonstrating how PBL bridges theoretical knowledge and real-world application.

From a practical perspective, the results offer concrete recommendations for teachers and school leaders in Kazakhstan, where traditional, teacher-centered methods remain dominant despite national policy commitments to sustainability. By highlighting PBL's potential to enhance students' critical thinking and engagement with locally relevant issues such as air pollution and biodiversity loss, the study supports the integration of learner-centered approaches into the school curriculum. Educators can use these findings to design and adapt PBL activities that foster stronger environmental awareness and responsible behaviors among young people, thereby preparing them to become active contributors to solve Kazakhstan's ecological challenges.

At the policy level, the study aligns directly with Kazakhstan's international and national commitments, including the Paris Agreement, the Strategy for Achieving Carbon Neutrality by 2060 (Decree No. 121, 2023), and the Environmental Code of the Republic of Kazakhstan (2007). By providing empirical evidence of PBL's effectiveness in improving environmental literacy—as reflected

in PISA science rankings—the findings can inform curriculum reform. Policymakers may draw on this evidence to prioritize innovative teaching methods, strengthen teacher professional development, and allocate resources more effectively to achieve Sustainable Development Goals 4 (Quality Education) and 13 (Climate Action).

Overall, this research not only advances academic understanding of PBL in environmental education but also offers actionable insights for practice and policy, contributing to the development of environmentally literate citizens in Kazakhstan and beyond.

1.8 Summary

Environmental literacy is crucial for addressing global ecological challenges and fostering sustainable development. Innovative teaching methods, such as PBL, can enhance students' understanding of environmental issues and promote responsible behaviors, supporting Kazakhstan's commitment to sustainability.

This chapter provides an overview of the study, starting with the background of EE in Kazakhstan. It introduces PBL as a learner-centered pedagogy that fosters critical thinking and practical application of knowledge to real-world environmental problems. The problem statement highlights the reliance on traditional teaching methods in Kazakhstani schools, which limits the development of environmental literacy. The research purpose and questions were presented, and key variables were defined. Then, the significance of the study was explained. The study's significance lies in its potential to inform curriculum development and policy in Kazakhstan, contributing to global EE efforts.

1.9 Outline of the Thesis

The thesis is structured into six chapters. The next chapter reviews relevant literature on environmental literacy and PBL. Chapter 3 describes the quasi-experimental methodology used in the study which is followed by Chapter 4 where the findings are presented along with data interpretation. A discussion of the results in the context of existing literature and theories are presented in Chapter 5.

Finally, Chapter 6 concludes the thesis, offering practical implications and recommendations for future research.

Chapter 2: Literature Review

This chapter reviews the existing literature on EE, environmental literacy, and PBL, with a focus on their applications in fostering sustainable practices and literacy in educational settings, particularly in Kazakhstan. The chapter is organized into four main sections. Firstly, a conceptual clarification of EE is provided, tracing its historical roots and developments in the 21st century. Secondly, environmental literacy is discussed, conceptualizing it and outlining its key components. Thirdly, PBL is examined as a pedagogical approach, including its conceptualization, advantages and disadvantages, and links to environmental literacy. Finally, the theoretical framework is developed based on a critical analysis of theoretical and empirical studies, grounding the study's use of PBL to enhance environmental literacy.

2.1 Conceptual Clarification: Environmental Education

The historical development of EE provides critical insights into its role in fostering global environmental awareness and sustainable practices. This section describes the evolution of EE in chronological order, highlighting key thinkers, events, and documents while offering critical reflection on their contributions and limitations. The section challenges the notion that EE is a recent phenomenon, acknowledges early pioneers, and evaluates gaps and biases to inform its future, particularly in relation to the present study on PBL and environmental literacy in Kazakhstan.

2.1.1 The Historical Roots of Environmental Education

In the 18th and 19th centuries, thinkers like Johann Wolfgang von Goethe, Jean-Jacques Rousseau, Alexander von Humboldt, Ernst Haeckel, Friedrich Froebel, John Dewey, and Maria Montessori shaped early environmental thought. They emphasized human-nature interconnectedness, experiential learning, and holistic education (Palmer, 1998). Their ideas encouraged direct engagement with the natural world. However, these perspectives were often Eurocentric and focused on individual enlightenment. They neglected broader social and economic dimensions, limiting their relevance to diverse global contexts.

Building on these philosophical foundations, early 20th-century educators translated abstract ideas into practical approaches. Sir Patrick Geddes advanced EE in the UK by linking environmental quality with education. He promoted experiential learning through direct environmental engagement (Sterling, 1992, as cited in Caravita et al., 2008). His approach was innovative but localized, lacking scalability for global challenges. In 1960, the National Rural Environmental Studies Association was formed. It became the National Association for Environmental Education (NAEE) in 1970, reflecting the rise of “environmental studies” integrating geography, history, and nature study (Palmer, 1998).

The post-World War II era saw EE’s formalization as a distinct field. The term “environmental education” emerged in 1948 at the International Union for the Conservation of Nature and Natural Resources (IUCN) meeting in Paris, attributed to Thomas Pritchard (Disinger, 1983). In the UK, the 1965 Keele University Conference united educationists and conservationists. It led to the creation of the Council for Environmental Education (CEE) in 1968 to promote EE practices (Palmer, 1998).

In 1969, William Stapp defined EE as a process to produce citizens knowledgeable about the biophysical environment and motivated to act on its problems (Stapp et al., 1969). This definition integrated knowledge, awareness, and action. The 1960s and 1970s brought global recognition for EE through international efforts. The 1968 UNESCO Biosphere Conference emphasized EE in curricula and global awareness (UNESCO, 1968). It advocated for national EE bodies. The 1970 IUCN and UNESCO meeting in Carson City defined EE as a process fostering values, skills, and attitudes to understand human-nature interdependence (IUCN, 1970). This definition was broad but lacked practical implementation guidance, especially for diverse educational systems.

The 1972 United Nations Conference on the Human Environment in Stockholm declared EE essential for all generations. It led to the establishment of the United Nations Environment Program (UNEP) in 1975 (UN, 1972). UNEP and UNESCO launched the International Environmental Education Program (IEEP) at the 1975 Belgrade Workshop. The Belgrade Charter outlined EE’s goals: fostering

awareness, equipping individuals with skills, and promoting new behaviors (UNEP, 1975). Its focus on individual action risked oversimplifying complex environmental challenges.

The 1977 Tbilisi Conference, attended by 66 UNESCO member states, produced the Tbilisi Declaration. This declaration became a global blueprint for EE. It emphasized EE's lifelong, interdisciplinary nature and its role in fostering awareness, knowledge, skills, and behaviors (UNESCO & UNEP, 1977). It highlighted ecological, social, and economic interdependence. However, its implementation faced challenges due to varying national priorities and resource disparities, especially in developing countries.

In 1990, the UNESCO and UNEP handbook defined EE's goal as developing a population equipped with knowledge, skills, attitudes, and commitment to address environmental issues (Bhushan et al., 1990). Its universal approach overlooked cultural differences, reducing its relevance in non-Western contexts. The 1992 Earth Summit in Rio de Janeiro produced Agenda 21. This document emphasized integrating environment and development education into all learning levels (UNCED, 1992). Its broad recommendations struggled to translate into actionable policies in resource-limited regions.

In conclusion, EE's historical evolution, from philosophical roots to global frameworks, reveals a progression driven by key thinkers and conferences. Critical reflection highlights persistent challenges: Western biases, individualistic approaches, and implementation gaps in diverse contexts. Understanding this trajectory informs the present study, which aims to develop environmental literacy through PBL in Kazakhstan. It aligns with EE's core principles of awareness, knowledge, and action, adapting historical frameworks to address local needs and systemic environmental challenges.

2.1.2 Environmental Education in 21st century

The 20th century brought many changes to the area of EE, which paved the way for even larger advancements in the 21st century. In 1992, the concept of Education for Sustainable Development (ESD) came forward at the Rio Earth Summit, where Agenda 21, especially Chapter 36, stressed how

education can support sustainability. As stated in Chapter 36, "For environmental and developmental education to truly make an impact, it must address the interactions within the physical and biological realms, the socio-economic context, and human growth—which could encompass spiritual elements" (UNCED, 1992, p. 320). This means that successful education in environment and development should adopt a complete and connected method, dealing with various sides of sustainability instead of just separate facts about the environment. Elder and Grunewald (2025) point out that Agenda 21 brought some key good outcomes, even though its achievements were not consistent. However, one big weakness of Agenda 21 was that it was too lengthy, complicated, and hard to read, share, and grasp (Sachs, 2012).

Subsequently, following Agenda 21, the United Nations Decade for Education for Sustainable Development (UN DESD) (2005–2014) became a central worldwide effort. In essence, the main idea behind the DESD was to create a world in which all people can gain from education and acquire the values, behaviors, and ways of living needed for a sustainable future and for helpful changes in society (UNESCO, 2004). During the Decade, ESD appeared as a teaching and learning approach designed to push forward sustainable development (SD). Starting as just a basic idea, ESD turned into a global movement (Hopkins, 2012), and perceptions of what it represents or should represent have shifted throughout the DESD. As per UNESCO's (2012) definition: "Education for Sustainable Development means including key sustainable development issues into teaching and learning; for example, climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption. It also requires participatory teaching and learning methods that motivate and empower learners to change their behavior and take action for sustainable development. Education for Sustainable Development consequently promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way" (p. 2). Within this definition, we can spot elements of two core features of ESD: the first relates to the content being taught, whereas the second deals with the instructional strategies.

Building on this foundation, following the DESD (2005–2014), the international community saw the importance of keeping up and improving the work of ESD. As a result, UNESCO started the Global Action Program (GAP) on ESD as a next step after the UN Decade of ESD, with the goal to speed up advancements in sustainable development and expand ESD activities across every part of education and learning. This program ran from 2015 until 2019. Furthermore, the GAP on ESD (2015–2019) had a vital part in building stronger links between global and local levels in sustainable education, by encouraging teamwork between policymakers, teachers, young leaders, and groups from civil society. In addition, partners in GAP pushed forward ESD by supporting full-school methods, giving power to young people, and improving teachers' skills with training that fits local situations. While a positive policy setting that matched the SDGs helped in making progress, there are still issues with awareness, available resources, and including everyone.

To further illustrate this integration, ESD serves as a vital component of the bold SDGs, especially Target 4.7, drawing from the UN Decade of ESD (2005-2014) and the GAP (2015-2019). Although ESD contributes to all 17 SDGs, it holds a key place in SDG 4's global education agenda as an essential element of quality education, fostering cross-cutting skills in cognitive, socio-emotional, and behavioral learning areas. SDG Target 4.7: "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (UNESCO, 2020, p. 14).

Boeve-de Pauw et al. (2015) concluded that ESD proves to be successful. When used as a teaching method, ESD assists in developing sustainability consciousness among learners. Their investigation showed that ESD effectively enhances students' knowledge and awareness regarding sustainability, particularly via interactive educational methods.

2.2 Environmental Literacy

This section examines the concept of environmental literacy as a foundational outcome of EE, particularly in the context of fostering sustainable behaviors and decision-making. It traces the historical and scholarly development of environmental literacy, defines its key elements, and analyzes its components to highlight their interconnections. This discussion is essential for understanding how PBL can enhance environmental literacy in Kazakhstani secondary education, addressing gaps in traditional approaches and promoting active engagement with environmental issues.

2.2.1 Conceptualizing Environmental Literacy

Environmental literacy has been conceptualized and refined over time by scholars and institutions, evolving to encompass more than just knowledge. This section traces the development of environmental literacy in chronological order, integrating key definitions and perspectives to clarify its multifaceted nature, including knowledge, skills, attitudes, and action.

Webster defines literacy as the ability to read and write (Webster, n.d.). When applied to environmental literacy, this suggests a foundational understanding of environmental issues. However, scholars argue that equating environmental literacy solely with knowledge oversimplifies the concept, as knowledge does not always lead to action (Finger, 1994).

In 1992, Roth provided a comprehensive definition, describing environmental literacy as a combination of environmental sensitivity, knowledge, skills, attitudes, values, personal investment, responsibility, and active involvement. Later in the same document, Roth refined this definition by subsuming environmental sensitivity, attitudes, and values under the term "affect," and personal investment, responsibility, and active involvement under "behavior," thus organizing environmental literacy into four strands: knowledge, skills, affect, and behavior (Roth, 1992). This framework emphasizes that environmental literacy involves not only intellectual understanding but also emotional engagement and active commitment to environmental issues.

Finger (1994) emphasized the disconnect between environmental knowledge and behavior, noting that understanding issues does not necessarily translate into environmentally responsible actions. This insight underscores the need for environmental literacy to include practical skills and motivational factors to bridge the gap between awareness and action.

In 2011, the North American Association for Environmental Education (NAAEE) defined an environmentally literate person as someone who makes informed decisions about the environment, both individually and collaboratively, and acts on these decisions to improve the well-being of individuals, societies, and the global environment while engaging in civic life (NAAEE, 2011). This definition broadens environmental literacy to encompass decision-making, social responsibility, and active participation in societal environmental efforts.

More recently, Fang et al. (2023) built on Roth's framework, suggesting that societal norms and values shape attitudes and values, which are central to environmental literacy. They argue that societal perceptions influence individuals' sensitivity to environmental issues and their approaches to addressing them, making environmental literacy a reflection of both individual and collective societal priorities.

In conclusion, environmental literacy has evolved from a narrow focus on knowledge to a comprehensive concept that integrates sensitivity, knowledge, skills, values, and civic engagement. Early definitions emphasized understanding, while later contributions highlighted the importance of affect, behavior, and societal influences. This progression underscores environmental literacy as a dynamic and multidimensional responsibility.

2.2.2 Components of Environmental Literacy

Environmental literacy is a multidimensional concept that includes the knowledge and comprehension of diverse environmental concepts, issues, and concerns, together with a collection of cognitive and emotional attitudes, a variety of cognitive capabilities and skills, as well as suitable behavioral approaches to use this knowledge and comprehension for arriving at well-founded and efficient decisions across various environmental settings. This aligns with the research works on EE,

which indicate that it contains four interconnected components: knowledge, attitudes, competencies, and behaviors that are responsible toward the environment (Cook & Berrenberg, 1981; Hungerford & Volk, 1990; Stern, 2000, as cited in Hollweg et al., 2011).

2.2.2.1 Knowledge. In environmental literacy, the knowledge aspect forms the foundational base. As outlined in the framework by Hollweg et al. (2011), learners are encouraged to consider their awareness regarding physical and ecological systems, social, cultural, and political systems, environmental problems, diverse ways to address these problems, along with methods for citizen engagement and initiatives. Meanwhile, Frick et al. (2004) identified various forms of knowledge, known as “factual knowledge,” “action-related knowledge,” and “effectiveness knowledge.” Factual knowledge involves the core understanding necessary for spotting environmental issues, including those stemming from human actions (Frick et al., 2004). System knowledge generally pertains to the workings of ecosystems (such as in Schahn & Holzer, 1990) or to insights into environmental concerns (as in Hines et al., 1986/87). If we regard environmental system knowledge as “knowing what,” action-related knowledge would equate to “knowing how,” involving familiarity with options for behavior and feasible steps to pursue (Ernst, 1994, as cited in Frick et al., 2004).

2.2.2.2 Dispositions. Dispositions play a crucial role in shaping behaviors toward the environment, whether they are beneficial or harmful. These dispositions encompass elements such as sensitivity, attitudes, concern, worldview, personal responsibility, locus of control or self-efficacy, along with motivation and intentions. It is believed that students' dispositions regarding the environment affect their readiness to identify and select from different value viewpoints, as well as their drive to engage in public discussions on environmental matters (Hollweg et al., 2011).

2.2.2.3 Competencies. Competencies are defined as skills and abilities that people know how and when to apply. These encompass identifying environmental problems, raising appropriate questions concerning environmental conditions and issues, examining environmental problems, exploring environmental issues in depth, assessing and forming personal opinions about environmental matters, applying evidence and knowledge to choose and justify one's own viewpoint for solving issues, as well as devising and evaluating plans across different scales or levels to address environmental problems. In broad terms, someone is regarded as competent when they can carry out a task on a repeated basis and achieving a particular standard of quality or exactness (Hollweg et al., 2011).

2.2.2.4 Behavior. Environmentally responsible behavior is the expression of knowledge, dispositions, and competencies within a context. It is also a source of experience that supports further learning and new behaviors (Hollweg et al., 2011).

These four components are tightly intertwined among themselves. Scholars have confirmed that environmental knowledge acts as a prerequisite for fostering positive attitudes toward the environment (Casaló & Escario, 2018; Casaló et al., 2019; Flamm, 2009; Kaiser et al., 1999; Lee et al., 2015). Liu et al. (2020) observed that environmental attitudes exert a notably positive influence on behavioral intentions related to the environment and on pro-environmental actions. Nevertheless, a number of other investigations have demonstrated that the direct link between environmental knowledge and pro-environmental behaviors tends to be weak (Laroche et al., 2002). Kollmuss and Agyeman (2002) reached the conclusion that no evident direct connection exists between general environmental knowledge and behaviors that support the environment. Such outcomes indicate that, even though people may possess some environmental knowledge, this element on its own does not lead to enhanced pro-environmental intentions and behaviors. Obviously, emotional reactions concerning environmental attitudes and intentions hinge on numerous situational factors.

2.3 PBL as a Pedagogical Approach

This section explores PBL as an innovative and student-centered pedagogical approach that aligns with the goals of EE and literacy. It conceptualizes PBL through its historical and theoretical foundations, evaluates its advantages and disadvantages based on empirical evidence, and examines its specific role in enhancing environmental literacy. This analysis is particularly relevant to the study's context in Kazakhstan, where PBL can address limitations in traditional education by promoting critical thinking and real-world application to local environmental challenges.

2.3.1 *Conceptualizing PBL*

PBL has developed over several decades into a prominent pedagogical approach, emphasizing experiential, learner-centered education to foster problem-solving, self-directed learning, and collaboration skills. Originating in medical education and expanding to various educational levels, PBL encourages students to tackle complex, authentic problems to prepare for real-world challenges. This section synthesizes key contributions to PBL's development, incorporating its theoretical foundations and practical applications.

The philosophical foundations of PBL originate in the progressive education movement of the early 20th century, with American philosopher John Dewey as a central figure. His educational theories emphasized learning as an experiential process connected to lived experiences, often termed “learning by doing.” Dewey (1938) argued that learning should be triggered by a “problem,” defined as an unclear situation requiring explanation, where learners draw on prior knowledge from everyday experiences to find solutions. This approach foreshadowed the cognitive revolution's focus on activating prior knowledge and contextualization.

In the late 20th century, PBL was formalized in medical education. Barrows and Tamblyn (1980) described PBL as an approach where students tackle authentic problems, such as patient cases, to acquire integrated knowledge and develop problem-solving skills. They noted its adaptability to both student-centered and teacher-centered settings, with teachers guiding problem selection and resource

use. Schmidt (1983) further refined PBL's framework, emphasizing small-group, tutor-guided collaboration to address complex medical problems, reinforcing its structured yet flexible nature.

Additionally, Hmelo-Silver (2004) defined PBL as “an instructional method in which students learn through facilitated problem solving” (p. 235). Students engage in self-directed learning (SDL) to identify knowledge gaps, apply new knowledge, and reflect on their strategies. Hmelo-Silver outlined five goals of PBL: developing flexible knowledge, effective problem-solving skills, SDL skills, collaboration skills, and intrinsic motivation, with teachers acting as facilitators rather than knowledge providers.

More recently, Savery (2015) provided another definition of PBL as “an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem” (p. 20). This definition emphasizes PBL's role in bridging theoretical knowledge with practical application, reinforcing its relevance in preparing students for real-world challenges.

2.3.2 Advantages and Disadvantages of PBL

PBL has gained considerable attention among educators as an effective pedagogical strategy. Many educators find PBL as a teaching approach quite attractive, since it provides a structured way to encourage active participation and collaborative learning. This is based on the idea that true learning happens when learners build and jointly create knowledge via social exchanges and independent exploration (Glaser & Bassok, 1989, Palincsar, 1998, as cited in Yew & Goh, 2016). Drawing from a range of studies, this review synthesizes the key advantages of PBL in developing essential student skills, such as critical thinking, independent learning, communication, and problem-solving. However, it also examines the disadvantages, including implementation challenges at teacher and student levels. The following sections outline these aspects, highlighting empirical evidence from recent research.

2.3.2.1 Advantages of PBL. Based on various research findings, an instructor who carefully plans and creates a solid PBL scenario can help students enhance their abilities in several domains. PBL's strength lies in its emphasis on real-world application and student-centered activities, which foster deeper engagement and skill development compared to traditional methods.

In terms of critical thinking, PBL demonstrates notable benefits. In a recent study, conducted in China, Zhou (2018) investigated the impact of PBL on critical thinking among 74 English-major sophomores from two classes at a university in Jiangxi Province (35 students in the experimental group and 39 in the control group). The results showed that learners demonstrated significant improvement in critical thinking dispositions such as analysis, openness, and fairness, as well as in critical thinking skills including analysis and interpretation. Similarly, Salari et al. (2018) examined the effects of PBL on the development of higher-order cognitive skills among 95 undergraduate nursing students enrolled in a Pediatric Nursing course at Islamic Azad University in Iran. The quasi-experimental study compared pure PBL, hybrid PBL, and conventional lecture-based instruction, and the results showed that PBL approaches were more effective than traditional lectures in engaging students in applying, analyzing, evaluating, and synthesizing information. Meanwhile, Seibert (2021) argues that PBL is particularly effective for engaging Generation Z students in higher-order critical thinking. This generation, often described as digital natives, prefers practical and experiential learning environments and is highly skilled at accessing information through technology. However, they may require additional opportunities to develop critical thinking, perseverance, and collaborative communication skills. PBL addresses these needs by engaging students in real-world problems that require analysis, evaluation, and collaborative decision-making. The PBL method matches the core meaning of critical thinking and the key components of thoughtful processes. For example, during PBL, students pose questions, examine data, combine ideas, explain meanings, draw conclusions, think logically, put concepts into practice, and employ intuition along with creativity. Moreover, PBL might include making concepts clearer, ranking issues by importance, figuring out what is already understood and what remains unknown, challenging

presuppositions, considering various perspectives, suggesting potential solutions, exploring options, and thinking back on the entire procedure. In addition, instructors can enhance effective decision-making by encouraging students to pinpoint sources that support collecting information and making choices.

PBL also supports independent learning by promoting lifelong educational habits. PBL fosters abilities related to dynamic and continuous education throughout life. It encourages independent learning by presenting learners with real issues and motivating them to engage in deeper understanding, meaning the "elaboration of knowledge at the time of learning" (Ali, 2019, p.76). Past investigations have indicated that PBL elevates students' drive and passion for studying. In particular, PBL appears to have a strongly favorable impact on learners' inner drive to acquire knowledge. Lessons structured around PBL help students achieve a transparent view of their personal learning journeys or progress. Moreover, most PBL activities include reflective journals, which additionally prompt learners to participate in introspection about their educational experiences. These introspective exercises, together with a sharp insight into personal learning, direct people to approach their educational pursuits more initiatively and persistently across their lifespan, rendering it a truly significant competence (Kang, 2012, as cited in Jang, 2019).

Regarding communication skills, PBL encourages interpersonal development through collaborative contexts. PBL utilizes authentic issues from the real world as a setting for education, which promotes teamwork by urging learners to exchange thoughts and approaches for addressing challenges (Das et al., 2023; Naik et al., 2024; Su, 2024). In the work of Lee and Son (2024), they merged PBL with the nursing methodology and observed a clear improvement in the mindset toward communication abilities among those in the test group, as opposed to the comparison group that stuck to conventional teaching sessions. Ningsih et al. (2025) indicated that PBL stood out as the top method for boosting competencies in both interacting and cooperating within Social Studies courses. The factor making PBL superior to alternative educational strategies stems from its stress on dynamic resolution of problems in practical environments, which inevitably calls for students to take part in thorough dialogue

and joint work. On the whole, such outcomes confirm that PBL supports not merely the gaining of information but also the growth of crucial relational talents through collective conversations, providing responses, and realistic applications.

Finally, PBL excels in cultivating problem-solving skills, which are vital for practical application. PBL uses real-life challenges as a base for teaching, which improves teamwork and sharpens the ability to solve problems by encouraging students to share views and methods for finding solutions (Koçoğlu & Kanadlı, 2025; Erdem et al., 2025). For instance, Koçoğlu and Kanadlı (2025) performed a second-order meta-analysis with several sets of data and found that PBL has a moderate positive effect on cognitive outcomes, including problem-solving skills, with an average effect size. This makes PBL better than other methods for developing these skills through real situations and group work. Similarly, Erdem et al. (2025) conducted a second-order meta-analysis synthesizing 20 first-order meta-analyses covering 469 independent studies on PBL in higher education. Their findings indicated that PBL has a significant and strong overall impact on student outcomes, with an adjusted mean effect size of $ES = 0.60$, particularly supporting the development of higher-order skills needed to address complex problems. Moreover, Chueh and Kao (2024) investigated the integration of PBL and agile methods in a university course on e-commerce and digital marketing in Taiwan. The study involved 59 undergraduate students, and the results showed significant improvements in learning outcomes and professional competencies, such as problem-solving, communication, and teamwork, based on pre- and post-test comparisons. The approach helped connect classroom learning with real-world industry needs. Also, Aslan (2021) investigated the use of PBL in live online classes at a university in Turkey using a quasi-experimental design with 45 undergraduate students. The findings indicated that students in the PBL group achieved significantly higher problem-solving skills and learning achievement than those in the control group after adjusting for pre-test scores. In general, these findings confirm that PBL helps not only with learning content but also with building key skills for handling difficulties through joint explorations, ongoing reviews, and practical uses.

2.3.2.2 Disadvantages of PBL. While PBL brings numerous advantages, it also presents certain drawbacks that educators and learners must consider. The systematic review by Ssali et al. (2025) shows that putting PBL into practice successfully in educational settings comes with various obstacles. For instance, it points out barriers on the side of instructors, such as inadequate preparation for guiding sessions, troubles in choosing suitable ways to evaluate progress, and issues with evaluating learners' adaptable abilities and overall achievements. Such elements may obstruct the proper use of PBL and reduce its possible benefits. Furthermore, countries that include PBL in their educational programs ought to offer specialized training to educators regarding the steps for applying PBL. On the learners' side, the analysis revealed that certain students struggle with group activities and may face difficulties in spotting problems or using what they know in real-life contexts. For individuals who do not have enough drive or capacity for self-assessment, the advantages of PBL and collaborative efforts could therefore be diminished. In these cases, it becomes essential for instructors to give tailored advice on working together with peers and managing one's own learning. However, these abilities are not easy for teachers to foster or for students to acquire, which underlines the need to start thorough training programs for educators on the best ways to carry out PBL in their teaching environments. One important challenge identified by Liu et al. (2020) relates to the need to provide differentiated instruction for students whose abilities fall below the expected grade level. In a qualitative study involving 25 sixth-grade science teachers from 18 schools in the United States, the authors found that teachers needed to provide additional guidance and support to these students while simultaneously addressing the needs of the rest of the class. Given the limited instructional time available in each lesson, this requirement was perceived as demanding, since student-centered approaches such as PBL require more time and effort than traditional teaching methods.

In conclusion, the literature underscores PBL's value in enhancing student skills, yet it calls for careful addressing of its challenges through targeted support and training to maximize its effectiveness in diverse educational contexts.

2.3.3 PBL and Environmental Literacy

PBL has become a strong teaching method that helps students gain important skills in many subjects. Studies show that students in PBL settings often do better than those in traditional lecture-based classes, especially when it comes to remembering information for a long time and using it in practical ways (Boye & Agyei, 2023; Jdaitawi, 2020; Yew & Goh, 2016). These findings suggest that PBL encourages deeper learning by letting students actively engage with material and apply it to real-life situations.

In PBL, students begin by encountering a problem, which becomes the central point for applying their reasoning and problem-solving skills. From there, they seek out the necessary information and knowledge to understand what caused the problem and explore possible ways to solve it. Key characteristics of PBL, as noted in the literature, include its focus on real-world issues, a student-centered approach, collaborative learning settings, and the pursuit of new information through self-guided study (Barrows & Tamblyn, 1980; Gijbels et al., 2005; Walker & Leary, 2009). These features create an engaging environment that promotes active learning and critical thinking.

Within the context of environmental education, these learning processes are closely connected to the concept of environmental literacy. Environmental literacy is one key skill needed to tackle today's global challenges, like sustainability. It involves understanding ecosystems, recognizing how human actions affect the environment, and being ready to make responsible choices (Hollweg et al., 2011). However, environmental literacy is not just about knowing facts—it requires critical thinking, analyzing complex problems, and solving them effectively (McBride et al., 2013). PBL fits well here because it focuses on active learning, asking questions, and solving real-world problems (Hmelo-Silver, 2004). For example, PBL can help students explore issues like sustainable development, think about human impacts on nature, and come up with practical solutions, making them more environmentally literate (Gök & Boncukçu, 2023). By working together and analyzing real environmental issues, PBL helps students build the skills needed to address sustainability challenges in a meaningful way.

For this reason, PBL is often highlighted in the literature as an effective approach for developing environmental literacy. PBL is particularly valuable for fostering environmental literacy, especially in the context of sustainable development education. According to Maclean and Pavlova (2017), PBL is a critical approach for enhancing the effectiveness of EE. Grounded in constructivism, PBL revolves around three essential elements: a problem that sparks learning, a teacher who acts as a facilitator, and collaborative group activities (Dolmans et al., 2005). This model encourages students to tackle authentic environmental challenges, such as those related to sustainability, by working together to analyze issues and propose practical solutions. Through this process, PBL not only cultivates environmental literacy but also equips students with the skills to address complex ecological problems responsibly (Gök & Boncukçu, 2023). By integrating real-world problems and collaborative inquiry, PBL fosters the development of informed, environmentally conscious individuals capable of contributing to sustainable practices.

Empirical studies further support the relationship between PBL and environmental literacy outcomes. Kuvac and Koc (2019) found that PBL significantly improved preservice science teachers' environmental attitudes compared with traditional instruction. After participating in a 10-week environmental science course structured around problem scenarios, the experimental group demonstrated more favorable environmental attitudes, indicating that learner-centered approaches such as PBL can support the effective goals of environmental education.

Cox and Amador (2025) implemented a semester-long environmental science course structured around an authentic environmental problem related to wastewater treatment and water quality. Using a PBL framework, students worked in groups to analyse environmental issues, identify knowledge gaps, and develop potential solutions while integrating knowledge from multiple scientific disciplines. The course design aimed to develop students' critical thinking, research, communication, and teamwork skills while allowing them to engage with practical environmental challenges and apply environmental science concepts in real-world contexts.

Lewinsohn et al. (2015) argue that PBL can strengthen ecological literacy by connecting ecological concepts with real-world environmental problems and professional decision-making contexts. In this approach, students analyse environmental issues, identify relevant ecological concepts, and develop evidence-based solutions, which helps them understand how ecological knowledge can be applied in practice. The authors suggest implementing PBL through activities such as simulated professional tasks, field courses, excursions, and digital simulations that allow students to investigate environmental problems and apply ecological methods. By engaging in these activities, students develop higher-level cognitive skills such as analysing environmental issues, evaluating ecological reasoning in professional practices, and designing solutions based on ecological science. As a result, PBL helps prepare future professionals to apply ecological knowledge in their careers and to participate effectively in multidisciplinary efforts aimed at solving environmental problems.

2.4 Theoretical Framework

The theory employed in this study is Lev Vygotsky's Theory of Social Constructivism, a developmental theory that emphasizes the critical role of social interaction in cognitive development. Vygotsky (1978) views learners as inherently social beings, whose ways of thinking are shaped and refined through interaction with others. According to this perspective, knowledge is not transmitted passively but is actively constructed through dialogue, negotiation, and shared experiences. Learning occurs in a discursive environment, where ideas are discussed, compared, and co-constructed among learners and facilitators. Through this process, students not only refine their own understanding but also contribute to the learning of others.

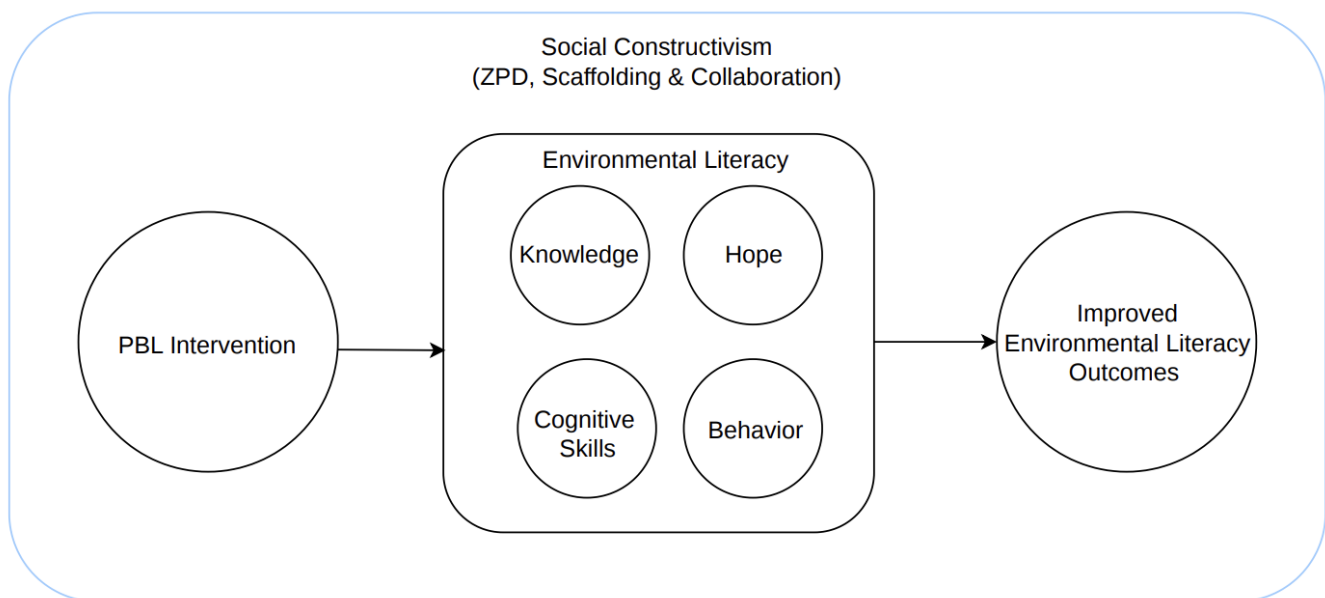
Vygotsky's theory introduces key concepts such as the Zone of Proximal Development (ZPD) and scaffolding, where learners are supported by more knowledgeable others to reach higher levels of understanding than they could achieve independently. In this view, teaching is most effective when it is learner-centered, collaborative, and focused on authentic tasks. As Dagar and Yadav (2016) explain, social constructivism promotes an interactive and participatory classroom environment, where both

teachers and students engage in meaningful exchanges that lead to joint knowledge construction. This theoretical lens aligns well with the PBL approach used in this study, as it supports student inquiry, cooperation, and active engagement in solving real-world environmental problems.

After reviewing the literature on PBL and its impact on environmental literacy, the following conceptual framework has been developed. This framework aligns with the study's aim, focusing on how a PBL intervention can enhance secondary school students' environmental literacy. The major components of the framework are: PBL intervention, which serves as the pedagogical tool, environmental literacy, conceptualized through Szczytko's (2019) dimensions: knowledge, hope, cognitive skills, and environmentally responsible behavior, and the anticipated outcomes, such as increased environmental awareness and responsible action. The following illustration (Figure 1) depicts the theoretical framework of this study.

Figure 1

Theoretical Framework of the Study



Grounded in social constructivist principles, the PBL intervention was designed around collaborative, real-world problem scenarios that required students to investigate environmental issues, generate solutions, and apply scientific knowledge through inquiry and discussion. The intervention was

implemented over six weeks and consisted of twelve lessons integrated into the regular biology curriculum. Lesson topics included bioaccumulation of toxic substances, renewable and non-renewable resources, balanced diets, and human health, each framed through authentic environmental problems intended to foster both science understanding and environmental literacy. The lessons incorporated key PBL features such as problem identification, collaborative inquiry, scaffolding, self-directed learning, and solution development. A detailed overview of the intervention plan, including lesson topics, learning objectives, and PBL scenarios, is provided in Appendix B (see Appendix B).

The PBL model encourages students to collaboratively explore real-world environmental problems, engage in critical thinking, and construct solutions. Grounded in Vygotsky's social constructivist theory, this approach emphasizes social interaction, scaffolding, and active learning. Through this interactive method, it is hypothesized that students will not only gain factual knowledge but also develop pro-environmental attitudes and behaviors.

Ultimately, the framework suggests that students exposed to PBL will show higher levels of environmental literacy compared to those in traditional instruction settings.

2.5 Summary

This chapter reviewed the key literature related to environmental education (EE), environmental literacy, and PBL. It first examined the historical development of EE, from early philosophical ideas about human–nature relationships to international frameworks such as the Tbilisi Declaration and more recent initiatives like Education for Sustainable Development and the Sustainable Development Goals.

The chapter then discussed environmental literacy as a multidimensional concept that includes knowledge, dispositions, competencies, and environmentally responsible behavior. Previous research shows that environmental knowledge alone is not enough to promote pro-environmental actions, highlighting the need for educational approaches that also develop skills, attitudes, and behavioral intentions.

Next, the chapter explored PBL as a student-centered pedagogical approach that promotes critical thinking, collaboration, and problem-solving through real-world problems. While PBL offers many benefits for developing higher-order skills, the literature also identifies several implementation challenges, such as the need for teacher preparation and additional instructional time.

Finally, the chapter presented the theoretical framework of the study, grounded in Vygotsky's social constructivist theory, which emphasizes learning through social interaction and collaboration. Based on this framework, the study proposes that a PBL intervention can enhance students' environmental literacy.

The next chapter describes the research methodology, including the research design, participants, instruments, and data analysis procedures used in this study.

Chapter 3: Methodology

This chapter presents the research design and methodology. First, the chapter provides a rationale for the quantitative research design. Second, the process of recruitment of the participants is described. Then, the chapter provides information on the tools used to collect the data and its analysis process. In addition, the intervention plan is thoroughly and visually explained. Lastly, the chapter discusses ethical considerations of the study.

3.1 Research Design

This research used a quantitative research approach, characterized by Creswell (2012) as “a need for an explanation of the relationship among variables” (p. 13). These variables can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. I understand my research as being quantitative because, as Creswell (2012) describes, my research includes the collection and analysis of numerical data gathered through standardized environmental literacy assessment tools administered before and after the implementation of a PBL intervention. This design allows for the measurement of changes in students’ environmental literacy, specifically in knowledge, dispositions, competencies, and behaviors.

Within the quantitative methodology, an experimental research design was employed, which is described by Creswell (2012) “determines whether an activity or materials make a difference in results for participants” (p. 21). This research assessed the impact of the PBL intervention on students’ environmental literacy by administering the PBL to one group and withholding it from the control group. Subsequently, the results were compared between the experimental and control groups to determine whether the PBL intervention influences environmental literacy outcomes.

Within the experimental designs, a quasi-experimental research design was selected, because it included assignment, but not random assignment, of participants to groups (Cresswell, 2012). It is necessary to work with intact groups such as existing school classes, as randomly assigning students to experimental and control groups could disrupt the normal flow of classroom learning.

This thesis implemented a pretest-posttest experimental design. As outlined by O'Dwyer and Bernauer (2013), this method permits researchers to "empirically compare the groups on the attribute that the treatment is designed to affect before implementation and following its application" (p. 178). Here, it is vital to examine the extent to which the PBL intervention altered the baseline assessments of students' environmental literacy to accomplish the study's goals of evaluating impacts.

3.2 Sampling Strategies

This thesis employed a purposeful sampling strategy, specifically applying a convenience sampling approach, to select participants from one private secondary school in Astana, focusing on seven-grade students. Purposeful sampling was chosen to intentionally select individuals who could provide the most relevant insights into the phenomenon under study, as it involves "intentionally select[ing] individuals and sites to learn or understand the central phenomenon" (Creswell, 2012, p. 206). The convenience sampling strategy was applied by selecting participants who are readily available within the chosen school, ensuring logistical feasibility while maintaining alignment with the study's objectives.

The decision to focus on seven-grade students is informed by their developmental stage, recognized as a critical period described as the "last best chance to avoid a diminished future" (Carnegie Council, 1989, as cited in McBeth et al., 2008). During early adolescence, students develop abstract thinking skills, a key component emphasized in EE frameworks (EPA, 1992, 1996; Hungerford, Peyton, & Wilke, 1980; NAAEE, 1999, 2000; NEEAC, 1996, 2000; Simmons, 1995; Stapp et al., 1969, 1979; UNESCO, 1978, as cited in McBeth et al., 2008). Research also indicated that middle school years are marked by significant transitions, including biological changes like puberty and brain maturation, as well as psychological and social shifts, which can lead to declines in academic motivation, engagement, and achievement due to mismatches between adolescents' developmental needs and the school environment (Eccles & Roeser, 2011). These transitions make seven-graders particularly suitable for interventions like PBL, which can counteract disengagement. Additionally, studies demonstrated that

seven-grade students can develop system thinking skills, crucial for environmental literacy, when engaged in earth systems-based curricula (Assaraf & Orion, 2005). Moreover, an "adolescent dip" in sustainability consciousness, encompassing environmental, social, and economic dimensions, typically peaks around ages 15–16, highlighting the importance of targeting earlier adolescence to mitigate this decline (Olsson & Gericke, 2016).

From a research perspective, focusing on this age group facilitates potential longitudinal follow-up as participants progress into high school and beyond. Therefore, selecting seven-grade students was essential to align the intervention with their developmental readiness to enhance environmental literacy, potentially counteracting motivational declines during adolescence.

The sample consisted of 80 students, divided equally into a control group ($n=40$) and an experimental group ($n=40$), drawn from intact classes within the selected school to ensure representation of typical seven-grade demographics in Astana while maintaining feasibility for in-depth implementation and observation. The sample size of 80 is determined based on a balance between statistical power and practical constraints common in educational research. Using intact classes enhances ecological validity, minimizes disruption, and aligns with the school's logistical realities, allowing for robust pre-post comparisons to examine the impact of PBL on environmental literacy. This purposive, convenience-based approach ensured a focused investigation of how PBL influences environmental literacy in this critical developmental stage.

Although 80 seventh-grade students (40 per group) were initially recruited, the final analyzed sample comprised 47 students (Cambridge curriculum instruction group $n = 22$; PBL group $n = 25$). Thirty-three cases were removed via listwise deletion due to incomplete responses on one or more ELI-A scales. Comparison of pre-test scores showed no systematic differences between retained and excluded participants, indicating data were missing at random. The implications of the reduced sample size are discussed in Chapter 6 (Limitations).

3.3 Data Collection Instruments

The Environmental Literacy Instrument for Adolescents (ELI-A) was the primary data collection instrument, a validated survey tool developed by Szczytko et al. (2019) to assess environmental literacy among adolescents (ages 11–18). The ELI-A is grounded in the conceptual framework of environmental literacy outlined in the Tbilisi Declaration (UNESCO & UNEP, 1977) and Hollweg et al. (2011), which emphasizes four core components: knowledge, affect (operationalized as hope), cognitive skills, and behavior. The survey is designed for use in formal and informal learning settings, the instrument was empirically validated through confirmatory factor analysis and structural equation modeling, demonstrating strong reliability and theoretical alignment (Szczytko et al., 2019). Subsequent research has consistently referenced and extended this foundational work. For example, Gibson et al. (2024) built directly upon the ELI-A framework to investigate students' affective dimensions toward environmental action through environmental hope, hopelessness, and response efficacy, adapting the Li and Monroe (2018) Climate Change Hope Scale to a broader environmental context. Similarly, Garner et al. (2025) used an adaptation of the affective subscale originally developed by Szczytko et al. (2019) to measure environmental stewardship attitudes, identifying two affective dimensions, particularly environmental hope and environmental despair that reflect adolescents' confidence and sense of control regarding environmental challenges. These studies show that the ELI-A is a flexible and useful tool for measuring different parts of environmental literacy, especially students' feelings, attitudes, and beliefs about the environment, in various educational and research settings.

The ELI-A consists of five parts, including demographic questions. It uses a mix of multiple-choice, Likert-scale, ranking, and frequency-based response formats to capture both objective knowledge and self-reported perceptions. The instrument was administered online via Qualtrics to ensure accessibility and ease of data entry. Participants were provided with clear instructions, and responses were anonymous to encourage honest reporting. Below is a detailed description of each

component, including scoring and psychometric properties based on the validation study by Szczytko et al. (2019).

Part 1: Ecological Knowledge

This section measures foundational understanding of ecological concepts, focusing on physical and ecological systems. It includes 10 multiple-choice questions, each with four response options and one correct answer. Questions cover topics such as nutrient cycles (e.g., "Phosphates are harmful in rivers because they: cause algae blooms that reduce oxygen in the water"), interspecies relationships (e.g., "Ecology is the study of the relationship between organisms and their environments"), population dynamics (e.g., "There are 150 longleaf pine trees per square kilometer... To which population characteristic does this information refer? population density"), energy sources (e.g., "What is the original source of energy for all living things on the earth's surface? the sun"), ecosystems (e.g., "What do you call all living organisms and nonliving parts of their environment? an ecosystem"), ecological processes (e.g., water cycle and succession), evolutionary biology (based on a diagram of bone structures in animal limbs, concluding "they evolved from a common ancestor"), soil ecology (e.g., role of organisms like worms in "recycling the remains of dead organisms"), and symbiotic relationships (e.g., mycorrhizae as "mutualism"). Each correct response is scored as 1 point, with a total possible score ranging from 0 to 10. Incorrect or unanswered questions receive 0 points.

Part 2: Environmental Hope

This section assesses affect through the lens of hope, conceptualized as a combination of agency (belief in one's ability to achieve goals) and pathways thinking (planning ways to meet goals), drawing from Snyder et al. (1991). It consists of 10 Likert-scale items (e.g., "I believe people will be able to solve most environmental problems," "I believe scientists will be able to find ways to solve environmental problems," "Even when some people give up, I know there will be a way to solve environmental problems"). Responses are rated on a 5-point scale from 1 (Strongly Disagree) to 5 (Strongly Agree), with some items reverse-coded (e.g., "The actions I can take are too small to help

solve environmental problems"). Items are averaged after reverse-coding, yielding a mean score from 1 to 5, where higher scores indicate greater environmental hope.

Part 3: Cognitive Skills

This section evaluates analytical skills in addressing environmental issues, focusing on the ability to prioritize questions for problem-solving. Participants read two short passages describing real-world environmental problems (e.g., "Striped Bass" scenario: declining fish populations due to overfishing, requiring sustainable management by a decision-maker like Daniel Pinder). For each passage, respondents rank five questions by importance (from 1 = Most Important to 5 = Least Important) in solving the problem. Questions vary in focus, such as scientific (e.g., biological impacts), social (e.g., stakeholder perspectives), economic (e.g., costs), or ethical considerations, distinguishing monological (single perspective) from multilogical (multi-perspective) thinking. Rankings are scored based on alignment with expert-determined priorities, emphasizing multilogical questions as more important. Total scores range from 0 to 10 (5 per scenario), with higher scores reflecting stronger cognitive skills.

Part 4: Behavior

This section captures self-reported engagement in pro-environmental behaviors. It includes 10 items asking about the frequency of activities (e.g., recycling, conserving energy, discussing environmental issues). Responses are on a 5-point scale from 1 (Never) to 5 (Always). Items are averaged for a mean score from 1 to 5, with higher values indicating more frequent pro-environmental behaviors.

Part 5: Demographics

This section was originally intended to collect background information for contextual analysis, including grade level, age, gender identity, and race/ethnicity. However, demographic questions were not included in the final survey. This decision was made because the study was conducted exclusively with Grade 7 students, and their grade level and approximate age were already known to the researcher.

Additionally, variables such as gender, and race/ethnicity were not considered essential for addressing the research questions of this study. Excluding demographic items also helped to minimize respondent burden and support participant anonymity, aligning with ethical standards for research involving adolescents.

3.4 Data Analysis Procedures

Once I got approval from the Nazarbayev University Institutional Research Ethics Committee (NU IREC), the study proceeded in three main steps. The first step focused on coordinating with school leaders, parents, and the students who might participate. We started by choosing a school based on convenience and accessibility, such as schools we already know or those nearby. Then, an invitation email was sent directly to the school. The email explained what the study is about, any possible risks or benefits, and details on the EE program. Next, because the participants are minors (adolescents between the ages of 13 and 18), it was necessary to obtain consent from their parents or legal guardians (Johnson & Christensen, 2020). The study used passive informed consent for parents in the intervention and group; if they the form was not returned, their consent was assumed. This method helps increase involvement while honoring parents' choices (Johnson & Christensen, 2020). Finally, once parental consent is obtained, assent forms were provided to the students, and the study was explained in clear, age-appropriate language to ensure they understand what participation involves.

The second step covered gathering and analyzing the data. The study began the pre-test and post-test once it had determined the intervention and control groups. In the pre-test, both groups completed the ELI-A during a break or a set class time. It is important to ensure baseline equivalence, meaning both groups have similar scores on environmental knowledge, environmental hope, cognitive skills, and behavior. This baseline check helps ensure any changes seen in posttest are due to the intervention, not differences that already exist (Anderson & Maxwell, 2018). This study used a paired samples t-test to spot any pre-test differences between groups. After the PBL intervention was carried out in the treatment

group, the posttest procedures were conducted. The data were collected during break time or a similar period in the posttest using the same ELI-A survey.

The third step involved data analysis conducted by an independent researcher using jamovi software with the jmv package. The data were first cleaned and subjected to descriptive statistics and assumption checks. Scoring of the ELI-A followed the guidelines provided by Szczytko et al. (2019), with each subscale adjusted proportionally to contribute to a total score of 100.

To evaluate changes within each group from pre-test to post-test, paired-samples t-tests were conducted. This analysis allowed for a direct comparison of students' environmental literacy scores across the two time points within each group (George & Mallery, 2019).

An analysis of covariance (ANCOVA) was performed to compare post-test total environmental literacy scores between the PBL and Cambridge curriculum groups while controlling for pre-test differences. This technique incorporates an additional continuous variable (the pre-test score) as a covariate, which may influence the dependent variable (Navarro & Foxcroft, 2025).

A mixed between–within analysis of variance (mixed ANOVA) was applied to compare changes in environmental literacy scores between the two groups over time. This method is particularly suitable for quasi-experimental pretest-posttest designs because it examines both within-subjects changes over time and between-subjects differences between groups, including potential interaction effects (Navarro & Foxcroft, 2025; Pallant, 2020). In this study, mixed ANOVA assessed main effects of time and group, as well as the time $\times$ group interaction.

Finally, correlation analysis was used to measure the strength and direction of relationships between the different components of environmental literacy. Pearson's correlation served as the primary test, while Spearman's correlation was also examined to reduce the influence of extreme scores and potential violations of normality assumptions, thereby ensuring more robust results (Field, 2018).

3.5 Intervention

The intervention aimed to enhance students' environmental literacy by embedding PBL within the Cambridge Lower Secondary Science curriculum. Spanning six weeks and encompassing 12 hours of instruction, it was tailored to align with the second term's biology units on health and applications of science. The Cambridge Lower Secondary Science curriculum promotes scientific thinking and the development of practical skills alongside conceptual knowledge. It helps students recognize the relevance of science to their everyday lives and equips them with the understanding and skills needed to succeed in later stages of education and to make informed decisions about sustainability issues and the environmental challenges facing the world (Cambridge International Education, n.d.).

This philosophy resonates strongly with the principles of PBL. The Cambridge curriculum's focus on scientific thinking, practical skills, and real-world sustainability issues creates a natural synergy with PBL's emphasis on collaborative inquiry, problem-solving, and authentic application of knowledge. The PBL process was organized using the Seven Jump framework outlined by Schmidt and Moust (2000), which provided a systematic sequence to facilitate student inquiry. This involved the following stages:

- Identifying and clarifying any unclear terminology in the problem context;
- Collaboratively pinpointing the core issue at hand;
- Generating initial hypotheses or explanations through brainstorming;
- Evaluating and refining these ideas through critical discussion;
- Establishing specific learning goals to direct further exploration;
- Engaging in self-directed or collaborative research to fill identified knowledge gaps;

Synthesizing and presenting insights to form a cohesive resolution, supported by teacher guidance and feedback (Schmidt & Moust, 2000; Wood, 2003).

Lessons were centered on authentic environmental questions that bridged scientific principles with practical applications. For instance, in the bioaccumulation topic, students investigated the impact

of toxic substances on ecosystems through an “environmental detectives” task. They explored a mystery illness in a river caused by pollutants accumulating in food chains, created models to show toxin transfer from plants to top predators, and identified pollution sources such as farms or factories. Students then proposed sustainable solutions, such as cleaner farming practices. The activity was linked to the environmental literacy survey by referencing algal blooms caused by phosphates, helping students understand how pollution reduces oxygen levels and harms aquatic populations (See Appendix B).

The program incorporated both explicit and implicit instructional strategies. Explicit methods focused on building foundational knowledge in environmental science, covering topics like ecological interactions, organismal biology, and physiological mechanisms. This content was deliberately mapped to the domains of the ELI-A, which assesses aspects such as ecological understanding, environmental optimism, cognitive abilities, and behaviors promoting sustainability. Implicit strategies, meanwhile, emphasized pedagogical practices that nurtured teamwork, introspection, and a sense of ecological stewardship (Szczytko et al., 2019).

Across the intervention, participants were prompted to link scientific ideas to real-world ecological challenges, formulate their own inquiries, and develop feasible interventions. Key priorities included cultivating investigative skills, holistic systems perspectives, and habits of reflection. The concluding session featured a reflective wrap-up exercise, followed by the deployment of the ELI-A questionnaire to gauge the initiative's influence on environmental literacy development.

The intervention’s program is visually represented in Appendix B.

3.6 Ethical Considerations

This research was conducted with a strong commitment to upholding ethical principles throughout all stages of the study. Ethical approval was obtained from the Research Ethics Committee at Nazarbayev University prior to data collection. In addition, formal permission was granted by the administration of the participating secondary school in Astana.

As participants are seventh-grade students (aged 12–13), special attention was given to obtaining informed parental consent and student assent. To mitigate the potential influence of the principal investigator (PI) as the students' biology teacher, the Head of the Science Department, who does not teach Grade 7, distributed consent and assent forms during Creative Breaks in October 2025. These forms, were provided in English, Russian, and Kazakh to ensure accessibility, clearly outlined the study's purpose, procedures, minimal risks (e.g., mild stress from surveys or group activities), benefits, and the voluntary nature of participation, emphasizing that students may withdraw at any time without consequences (Creswell, 2012). Parents had at least three days to review materials and contact the PI or lab assistant with questions via email, phone, or optional in-person/online information sessions. Signed forms were collected via a designated drop box by a lab assistant to maintain confidentiality. The study explained to students in age-appropriate language to ensure understanding and comfort, with assent obtained only after parental consent.

To protect participants' privacy, all data were collected anonymously. No identifying information was linked to student responses, and pseudonyms were used during analysis and reporting. Data was stored securely and accessed only by the researcher. Findings were presented in aggregate form to avoid the risk of identifying individuals or the school.

The research also adhered to the principle of non-maleficence. The intervention was designed to align with the school's existing science curriculum, ensuring that it supported, rather than disrupted, students' learning. Efforts were made to create a safe, respectful, and inclusive classroom environment throughout the intervention period.

Finally, transparency was maintained at all stages of the study. Students, parents, and school staff were kept informed about the aims and procedures of the research. Upon completion, the school was offered a summary of the findings to contribute to future teaching and learning practices.

3.7 Summary

In conclusion, this chapter has outlined all methodological procedures, including research methods, sampling, data collection techniques, and ethical considerations employed to address the research questions. The rationale for selecting these specific methodologies has been justified and supported by various literature and sources. Additionally, a detailed description of the intervention program is presented in Appendix B, while also addressing and considering the ethical issues related to the study.

Chapter 4: Findings

This chapter presents the findings of the quantitative data analysis conducted to examine the effect of a Problem-Based Learning (PBL) intervention on students' environmental literacy in one secondary school in Astana. In this study, environmental literacy was defined as a multidimensional concept consisting of environmental knowledge, environmental hope, cognitive skills, and responsible environmental behavior. The main aim of the analysis was to determine whether participation in the PBL intervention led to statistically significant changes in students' environmental literacy outcomes and to examine the relationships among its key components after the intervention.

To address the research questions and test the hypotheses, I conducted several statistical analyses using *jamovi* software. Paired-samples t-tests were performed to examine differences between pre-test and post-test scores within each group (Cambridge curriculum and PBL). This test is suitable when the same participants are measured on two occasions, as was the case in this study where the same students completed both the pre-test and post-test.

I used pre-test environmental literacy scores as a covariate in an analysis of covariance (ANCOVA) to control for any initial differences between the groups and to enable a more accurate comparison of post-test results between the PBL and Cambridge curriculum groups. In addition, I conducted a mixed between-within subjects analysis of variance (Mixed ANOVA) to examine changes in environmental literacy and its components over time (pre-test to post-test), differences between the PBL and Cambridge curriculum groups, and the interaction between time and group. This analysis helped determine whether the intervention influenced students' environmental literacy development differently across the two instructional approaches. Furthermore, I conducted correlation analyses to examine the strength and direction of relationships among the four components of environmental literacy—ecological knowledge, environmental hope, cognitive skills, and responsible environmental behavior—following the intervention.

This chapter is organized into three main sections. The first section presents the results related to research question 1 and examines the effects of the PBL intervention on students' environmental literacy outcomes. The second section reports the findings related to research question 2, focusing on the relationships among the environmental literacy dimensions after the intervention. The final section summarizes the key findings of the chapter.

4.1 Effects of the PBL Intervention on Environmental Literacy

RQ1: To what extent does a PBL intervention influence secondary school students' environmental literacy in Astana, Kazakhstan?

H1: The PBL intervention has a statistically significant effect on students' environmental literacy, including knowledge, hope, skills, and responsible behavior.

Paired-samples t-tests were conducted to examine changes in students' environmental literacy results from pre-test to post-test for the Cambridge curriculum instruction group and the PBL group separately. The analyses compared students' scores on environmental knowledge, hope, cognitive skills, responsible environmental behavior, and total environmental literacy before and after the instructional period.

4.1.1 Total Environmental Literacy Scores

An analysis of covariance (ANCOVA) was conducted to examine differences in post-test total environmental literacy between the PBL and control groups while controlling for pre-test scores. Table 1 summarizes the ANCOVA results examining post-test total environmental literacy scores between the PBL and control groups, controlling for pre-test scores.

Table 1

ANCOVA Results for Total Environmental Literacy Scores

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>	η^2p
Total-Pre	1190.2	1	1190.2	12.603	<.001	0.223

Group	28.3	1	28.3	0.300	0.587	0.007
Residuals	4155.3	44	94.4			

Results indicated that pre-test scores significantly predicted post-test performance, $F(1, 44) = 12.60, p < .001$, partial $\eta^2 = .223$. However, after adjusting for baseline differences, no significant effect of Group was found, $F(1, 44) = 0.30, p = .587$, partial $\eta^2 = .007$. Levene's test confirmed that the assumption of homogeneity of variances was met ($p = .214$), as shown in Table 2.

Table 2

Homogeneity of Variance Test for Total Environmental Literacy

F	df1	df2	p
1.59	1	45	0.214

These results suggest that post-test differences in total environmental literacy were primarily attributable to pre-existing group differences rather than the PBL intervention.

4.1.2 The Effects of the PBL Intervention on Environmental Literacy Components Scores

Mixed between–within ANOVA was conducted to compare changes in environmental knowledge, environmental hope, cognitive skills, and responsible environmental behavior between the PBL and control groups over time. The results for each component are presented separately.

4.1.2.1 Knowledge. The results of the mixed ANOVA examining pre-test and post-test knowledge scores of the PBL and control groups are presented in Table 3.

Table 3***Mixed ANOVA Results of Pre-Test and Post-Test Knowledge Scores of the PBL and Control Groups***

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>	η^2p
Within Subjects Effects						
Time	48.7	1	48.7	4.71	0.034	0.095
Time * Group	20.8	1	20.8	2.01	0.163	0.043
Residuals	465.5	45	10.3			
Between Subjects Effects						
Group	178	1	178.5	6.60	0.014	0.128
Residuals	1217	45	27.0			

Note. Type 3 Sums of Squares

Examination of the ANOVA summary table indicated a significant main effect of Time on knowledge scores, $F(1, 45) = 4.71$, $p = .035$, partial $\eta^2 = .095$, indicating that students' knowledge scores increased significantly from pre-test to post-test across both groups. However, the Time $\times$ Group interaction was not statistically significant, $F(1, 45) = 2.01$, $p = .163$, partial $\eta^2 = .043$, suggesting that changes in knowledge scores over time did not differ significantly between the PBL and control groups.

In addition, a significant main effect of Cambridge group was observed, $F(1, 45) = 6.60$, $p = .014$, partial $\eta^2 = .128$, indicating that one group demonstrated overall higher knowledge scores than the other across measurement times.

4.1.2.2 Hope. The results of the mixed ANOVA examining pre-test and post-test hope scores of the PBL and control groups are presented in Table 4.

Table 4***Mixed ANOVA Results of Pre-Test and Post-Test Hope Scores of the PBL and Control Groups***

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>	η^2p
Within Subjects Effects						
Time	4.499	1	4.999	1.4747	0.231	0.032
Time * Group	0.271	1	0.271	0.0887	0.767	0.002
Residuals	137.295	45	3.051			
Between Subjects Effects						
Group	0.121	1	0.121	0.0128	0.911	0.000
Residuals	427.148	45	9.492			

Note. Type 3 Sums of Squares

Examination of the ANOVA summary table revealed that the main effect of Time was not statistically significant, $F(1, 45) = 1.47$, $p = .231$, partial $\eta^2 = .032$, indicating that students' hope scores did not change significantly from pre-test to post-test across both groups.

In addition, the Time $\times$ Group interaction was not statistically significant, $F(1, 45) = 0.09$, $p = .767$, partial $\eta^2 = .002$, suggesting that changes in hope scores over time did not differ between the PBL and control groups. Furthermore, the main effect of Group was not significant, $F(1, 45) = 0.01$, $p = .911$, partial $\eta^2 = .000$, indicating no overall differences in hope levels between the two groups across measurement times.

4.1.2.3 Cognitive Skills. The results of the mixed ANOVA examining pre-test and post-test cognitive skills scores of the PBL and control groups are presented in Table 5.

Table 5***Mixed ANOVA Results of Pre-Test and Post-Test Cognitive Skills Scores of the PBL and Control Groups***

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>	η^2_p
Within Subjects Effects						
Time	1.52	1	1.52	0.0487	0.826	0.001
Time * Group	32.03	1	32.03	1.0260	0.317	0.022
Residuals	1404.83	45	31.22			
Between Subjects Effects						
Group	260	1	259.7	4.60	0.037	0.093
Residuals	2540	45	56.4			

Note. Type 3 Sums of Squares

Examination of the ANOVA summary table indicated that the main effect of Time was not statistically significant, $F(1, 45) = 0.05$, $p = .826$, partial $\eta^2 = .001$, suggesting that students' cognitive skills scores did not change significantly from pre-test to post-test across both groups.

Furthermore, the Time $\times$ Group interaction was not statistically significant, $F(1, 45) = 1.03$, $p = .317$, partial $\eta^2 = .022$, indicating that changes in cognitive skills over time did not differ significantly between the PBL and control groups. However, a significant main effect of Group was observed, $F(1, 45) = 4.60$, $p = .037$, partial $\eta^2 = .093$, suggesting that one group demonstrated overall higher cognitive skills scores than the other across measurement times. The effect size for the group factor was moderate.

4.1.2.4 Behavior. The results of the mixed ANOVA examining pre-test and post-test responsible behavior scores of the PBL and control groups are presented in Table 6.

Table 6***Mixed ANOVA Results of Pre-Test and Post-Test Behavior Scores of the PBL and Control Groups***

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>	η^2p
Within Subjects Effects						
Time	161.04	1	161.04	4.8435	0.033	0.097
Time * Group	1.61	1	1.61	0.0485	0.827	0.001
Residuals	1496.18	45	33.25			
Between Subjects Effects						
Group	84.4	1	84.4	2.60	0.114	0.055
Residuals	1460.1	45	32.4			

Note. Type 3 Sums of Squares

Examination of the ANOVA summary table indicated a significant main effect of Time, $F(1, 45) = 4.84$, $p = .033$, partial $\eta^2 = .097$, indicating that students' responsible behavior scores increased significantly from pre-test to post-test across both groups.

However, the Time $\times$ Group interaction was not statistically significant, $F(1, 45) = 0.05$, $p = .827$, partial $\eta^2 = .001$, suggesting that the magnitude of change in responsible behavior over time did not differ significantly between the PBL and control groups. In addition, the main effect of Group was not statistically significant, $F(1, 45) = 2.60$, $p = .114$, partial $\eta^2 = .055$, indicating no overall differences in responsible behavior scores between groups across measurement times.

Overall, Hypothesis 1 was partially supported. The PBL intervention led to a statistically significant improvement in students' responsible environmental behavior; however, no significant effects were found for total environmental literacy, environmental hope, knowledge, or cognitive skills.

4.2 Within-Group Changes in Environmental Literacy Scores: Cambridge vs. PBL

RQ2: Is there a significant difference between students who experienced the PBL intervention and those who received Cambridge curriculum instruction in terms of post-test environmental literacy scores?

H2: There is significant difference between the PBL group and the Cambridge curriculum instruction group in post-test environmental literacy scores.

4.2.1 Cambridge Curriculum Instruction Group. Table 7 summarizes the paired-samples t-test results for the Cambridge instruction group comparing pre-test and post-test environmental literacy scores.

Table 7

Paired-Samples t-Test Results for Pre-Test and Post-Test Environmental Literacy Scores in the Cambridge Instruction Group

	t	df	p	Mean Difference	SE	Cohen's d	95% CI [LL, UL]
Knowledge	-2.31	21	.031	-2.39	1.03	-0.49	[-0.93, -0.004]
Hope	0.79	21	.439	0.33	0.42	0.17	[-0.26, 0.59]
Cognitive	-0.89	21	.382	-1.43	1.60	-0.19	[0.061, 0.23]
Behavior	0.22	21	.828	0.23	1.03	0.05	[-0.37, 0.46]
Total	-1.49	21	.152	-3.25	2.18	-0.032	[-0.74, 0.12]

Note. Mean difference = Pre – Post.

For the Cambridge instruction group ($n = 22$), the paired-samples t-test indicated a statistically significant increase in students' environmental knowledge scores from pre-test to post-test, $t(21) = -2.31$, $p = .031$. The mean difference was -2.39 ($SE = 1.03$), with a 95% confidence interval ranging from -0.93 to -0.04 . The effect size was moderate (Cohen's $d = 0.49$), suggesting a meaningful improvement in environmental knowledge.

No statistically significant differences were observed for environmental hope, $t(21) = 0.79$, $p = .439$, cognitive skills, $t(21) = -0.89$, $p = .382$, responsible environmental behavior, $t(21) = 0.22$, $p =$

.828, or total environmental literacy, $t(21) = -1.49$, $p = .152$. Effect sizes for these outcomes were small, indicating minimal changes over the instructional period.

4.2.2 PBL Group. Table 8 summarizes the paired-samples t-test results for the PBL group comparing pre-test and post-test environmental literacy scores.

Table 8

Paired-Samples t-Test Results for Pre-Test and Post-Test Environmental Literacy Scores in the PBL Group

	t	df	p	Mean Differen ce	SE	Cohen's d	95% CI [LL, UL]
Knowledge	-0.59	24	.564	-0.50	0.85	-0.12	[-0.51, - 0.28]
Hope	0.96	24	.346	0.55	0.57	0.19	[-0.21, 0.59]
Cognitive	0.55	24	.585	0.92	1.65	0.11	[-0.28, 0.50]
Behavior	-3.46	24	.002	-1.44	0.42	-0.69	[-1.12, 0.25]
Total	-0.22	24	.825	-0.48	2.16	-0.04	[-0.44, 0.35]

Note. Mean difference = Pre – Post.

For the PBL group ($n = 25$), the paired-samples t-test showed a statistically significant increase in students' responsible environmental behavior scores following the intervention, $t(24) = -3.46$, $p = .002$. The mean difference was -1.44 ($SE = 0.42$), with a 95% confidence interval ranging from -1.12 to -0.25 . The effect size was medium to large (Cohen's $d = 0.69$), indicating a substantial improvement in students' responsible environmental behavior.

In contrast, no statistically significant differences were found between pre- and post-test scores for environmental knowledge, $t(24) = -0.59$, $p = .564$, environmental hope, $t(24) = 0.96$, $p = .346$,

cognitive skills, $t(24) = 0.55$, $p = .585$, or total environmental literacy, $t(24) = -0.22$, $p = .825$. Effect sizes for these variables were small, suggesting limited change across the intervention period.

4.3 Relationships among Post-Test Environmental Literacy Components

RQ3: What is the relationship between students' environmental knowledge, hope, cognitive skills, and environmentally responsible behavior following the PBL intervention?

H3: There are statistically significant relationships among students' environmental knowledge, hope, skills, and responsible behavior after the PBL intervention.

A correlation analysis was conducted to examine the relationships among students' post-test environmental knowledge, hope, cognitive skills, and responsible environmental behavior following the PBL intervention. Pearson's product-moment correlation coefficients were calculated as the primary analysis, with Spearman's rank-order correlations reported to confirm the robustness of the findings. The level of statistical significance was set at $p < .05$.

Table 9***Correlations among Post-Test Environmental Literacy Components in the PBL Group***

	Knowledge	Hope	Cognitive	Behavior
Knowledge	-			
Hope	.203 (.197) p = .331 95% CI [-.21, .55]			
Cognitive	.566** (.546**) p = .003 95% CI [.22, .79]	.162 (.078) p = .440 95% CI [-.25, .52]		
Behavior	-.097 (.091) p = .646 95% CI [-.47, .31]	.270 (.192) p = .193 95% CI [-.14, .60]	-.090 (-.029) p = .667 95% CI [-.47, .32]	-

Note. Values are Pearson's r ; values in parentheses are Spearman's ρ .

$N = 25$, $df = 23$.

95% confidence intervals are reported in brackets. |

$p < .05^*$, $p < .01^*$, $*p < .001$.

As shown in Table 9, the analysis demonstrated a moderate, positive, and statistically significant relationship between post-test environmental knowledge and post-test cognitive skills ($r = 0.566$, $p = .003$). The 95% confidence interval did not include zero (95% CI [0.220, 0.786]), indicating a reliable association. This result was further supported by Spearman's correlation ($\rho = 0.546$, $p = .005$), suggesting that students with higher levels of environmental knowledge also tended to demonstrate stronger environmental cognitive skills after the intervention.

In contrast, no statistically significant correlations were found between post-test hope and the other environmental literacy components, including knowledge ($r = 0.203$, $p = .331$), cognitive skills (r

= 0.162, $p = .440$), and responsible behavior ($r = 0.270$, $p = .193$). Similarly, responsible environmental behavior was not significantly correlated with environmental knowledge ($r = -0.097$, $p = .646$), cognitive skills ($r = -0.090$, $p = .667$), or hope ($r = 0.270$, $p = .193$). All corresponding confidence intervals included zero, indicating weak or negligible associations.

Overall, the correlation analysis partially supported Hypothesis 2, demonstrating a significant positive relationship between environmental knowledge and cognitive skills, while no significant relationships were observed involving hope or responsible environmental behavior at the post-test stage.

4.4 Summary

This chapter presented the findings of the quantitative data analysis conducted to examine the effect of a PBL intervention on students' environmental literacy in one secondary school in Astana. Paired-samples t-tests, mixed between-within ANOVA, ANCOVA, and correlation analysis were used to address the research questions of the study.

The results showed that students in the Cambridge instruction group demonstrated a statistically significant increase in environmental knowledge, while students in the PBL group showed a statistically significant improvement in responsible environmental behavior. No significant changes were found for total environmental literacy in either group. The ANCOVA results that post-test environmental literacy scores were mainly explained by pre-test differences rather than by the PBL intervention.

The mixed ANOVA findings showed significant overall effects of time for environmental knowledge and responsible environmental behavior across both groups, with no significant interaction effects between time and group. The correlation analysis showed a statistically significant positive relationship between environmental knowledge and cognitive skills in the PBL group, while no significant relationships were found for environmental hope or responsible environmental behavior.

The next chapter discusses these findings in relation to existing literature and the theoretical framework of the study.

Chapter 5: Discussion

This chapter provides an interpretation and discussion of the findings obtained from the quantitative analysis conducted to examine the effects of the Problem-Based Learning (PBL) intervention on students' environmental literacy. The purpose of this study was to explore how integrating PBL into biology lessons influenced students' environmental knowledge, hope, cognitive skills, and responsible environmental behavior in one secondary school in Astana. The chapter interprets the results in relation to the research questions, hypotheses, and relevant literature on environmental education and student-centered learning approaches.

To address the research purpose, the following research questions and hypotheses guided the study:

RQ1: To what extent does the PBL intervention influence students' environmental literacy (knowledge, hope, cognitive skills, and responsible behavior)?

H1: The PBL intervention significantly influence students' environmental literacy components.

RQ2: Is there a significant difference between students who experienced the PBL intervention and those who received Cambridge curriculum instruction in terms of post-test environmental literacy scores?

H2: There is a significant difference between the PBL group and the Cambridge curriculum instruction group in post-test environmental literacy scores.

RQ3: What is the relationship between students' environmental knowledge, hope, cognitive skills, and environmentally responsible behavior following the PBL intervention?

H3: There are significant relationships among environmental knowledge, hope, cognitive skills, and responsible environmental behavior following the intervention.

This chapter discusses the key findings in relation to each research question and hypothesis, compares the results with previous research, and considers possible explanations for the observed

outcomes. It also highlights the implications of the findings for classroom practice, environmental education, and future research, particularly within the context of secondary education in Kazakhstan.

5.1 Effects of the PBL Intervention on Environmental Literacy

The results of this study showed no statistically significant effect of the PBL intervention on total environmental literacy when pre-test differences were controlled. This finding partially contrasts with previous research reporting that PBL significantly improves students' environmental literacy (Roshayanti et al., 2019).

Several studies have demonstrated that PBL can enhance students' environmental understanding and sustainability awareness by engaging them in real-world environmental problems and collaborative inquiry. For instance, Basche et al. (2016) implemented a PBL intervention that lasted for the entirety of one school year, allowing sustained engagement with locally relevant environmental issues. This long-term exposure resulted in improved students' attitudes, engagement, confidence, and ability to apply scientific knowledge to real-world environmental contexts. In contrast, Gök and Boncukçu (2023) conducted a shorter PBL intervention lasting three weeks (12 lessons), which led to significant improvements in environmental attitudes and problem-solving skills but showed limited impact on environmental behavior. These findings suggest that while short-term interventions can positively influence certain components of environmental literacy, longer-term interventions may be necessary to achieve broader and more sustained changes across multiple dimensions.

However, the lack of significant improvement in total environmental literacy in the present study may be explained by the relatively short duration of the intervention. Previous research suggests that environmental literacy develops gradually and requires sustained exposure to environmental learning experiences and opportunities for real-life application. Importantly, Szczytko et al. (2019) did not examine a short-term intervention but validated an environmental literacy instrument using data collected across an academic year, reinforcing the idea that environmental literacy is typically developed and assessed over longer timeframes.

Another possible explanation relates to the significant effect of pre-test scores on post-test outcomes. This finding suggests that students' initial levels of environmental literacy played an important role in shaping their post-test performance. It is possible that students who entered the intervention with stronger prior knowledge, attitudes, or experiences were better positioned to benefit from the instructional period. Previous environmental literacy research similarly indicates that demographic and experiential factors, such as socioeconomic background and contact with nature, are associated with students' environmental attitudes and behaviors (Negev et al., 2008).

However, similar findings of modest or mixed outcomes have also been reported in environmental and sustainability education research, with some studies noting limited or inconsistent effects of educational programs on environmental literacy components (Cincera et al., 2023).

5.1.1 Environmental Knowledge

The results revealed that environmental knowledge increased significantly over time across both groups. However, the PBL intervention did not produce a significantly greater increase compared to Cambridge instruction. Interestingly, the Cambridge instruction group demonstrated a statistically significant improvement in knowledge, whereas the PBL group did not show significant knowledge gains.

This finding suggests that the Cambridge curriculum, with its structured content coverage and emphasis on conceptual understanding, may support the acquisition of factual environmental knowledge within a short instructional period. It is also possible that students' gains were influenced by prior exposure to environmental topics embedded in the Cambridge science curriculum, as well as broader school-level factors, such as school policies and sustainability-related practices that may have reinforced environmental learning. Additionally, direct teaching approaches often emphasize structured content delivery, which may further support short-term knowledge acquisition.

Previous research suggests that PBL emphasizes inquiry, collaboration, and problem-solving processes rather than the simple transmission of factual knowledge (Ayerbe-López & Perales-Palacios,

2023). As a result, improvements in environmental literacy within PBL settings may require longer instructional periods to become fully evident, particularly when interventions are of short duration (Gök & Boncukçu, 2023). Therefore, the absence of statistically significant improvement in knowledge within the PBL group does not necessarily indicate ineffectiveness of the intervention but may instead reflect differences in instructional focus and the relatively short duration of the intervention.

5.1.2 Environmental Hope

The findings showed no statistically significant changes in environmental hope across time or between groups. This suggests that the PBL intervention did not produce measurable changes in students' environmental hope or sense of optimism regarding environmental issues during the intervention period.

Environmental literacy research suggests that affective components such as hope and attitudes are complex and highly variable, influenced by socio-cultural and contextual factors beyond formal instruction (Szczytko et al., 2019). Students' beliefs about environmental issues may be shaped by social context, family values, and media exposure. Consequently, short-term classroom interventions may have limited impact on these affective dimensions.

Recent research highlights the importance of the affective dimension in environmental education, including emotional engagement, values, and motivation for action. At the same time, affective learning outcomes are often less visible and less easily assessed within formal education systems, which tend to prioritize measurable cognitive outcomes (Lovren & Jablanovic, 2023). This may explain the limited change in environmental hope observed in the present study and suggests that sustained engagement with environmental issues may be necessary to support the development of positive environmental attitudes and optimism.

Previous studies suggest that positive environmental attitudes and confidence can be strengthened through sustained engagement with real-life environmental issues and authentic problem-solving experiences (Basche et al., 2016). Providing students with opportunities to implement

environmental solutions and observe tangible outcomes may therefore be necessary to strengthen environmental hope.

5.1.3 Cognitive Skills

No significant changes were observed in students' environmental cognitive skills across time or between groups. Although one group demonstrated higher overall cognitive skills scores, the PBL intervention itself did not lead to significant improvement in this component.

This finding may be related to the duration of the intervention and students' prior experience with PBL. Previous research suggests that inquiry-based approaches such as PBL support the development of higher-order thinking skills, including analysis and problem-solving, particularly when implemented consistently over time and across learning contexts (Heystek et al., 2025). Students who are new to PBL may initially focus on understanding tasks and collaboration rather than fully developing advanced cognitive skills.

It is also possible that the relatively short duration of the intervention limited opportunities for students to practice higher-order thinking skills within environmental contexts. Previous research suggests that inquiry-based and constructivist approaches such as PBL can support the development of critical thinking and problem-solving skills, particularly when implemented consistently over time (Heystek et al., 2025). Extended exposure to PBL across multiple units or subjects may provide greater opportunities for the development and consolidation of cognitive skills, potentially leading to more measurable changes over time.

Nevertheless, the correlation analysis revealed a significant positive relationship between environmental knowledge and cognitive skills in the PBL group. This finding aligns with environmental literacy frameworks suggesting that knowledge forms a foundation for the development of cognitive skills and informed decision-making (Szczytko et al., 2019).

5.1.4 Behavior

One of the most notable findings of this study was the statistically significant improvement in environmentally responsible behavior among students in the PBL group. This result suggests that participation in PBL encouraged greater reflection on environmental issues and fostered the adoption of more responsible environmental actions.

Environmental education research has long recognized that the development of pro-environmental behavior remains one of the most challenging objectives of environmental literacy. Early theoretical frameworks emphasize that knowledge alone is insufficient to generate behavioral change; instead, meaningful action requires the integration of cognitive, affective, and behavioral components (Hollweg et al., 2011). Students must not only comprehend environmental issues but also feel motivated and empowered to act upon them. Similarly, Kollmuss and Agyeman (2002) contend that pro-environmental behavior arises from a complex interplay of internal and external factors, including values, attitudes, emotional engagement, social context, and opportunities for action. Consequently, behavioral change is often gradual and may not manifest immediately following short-term instructional interventions. This perspective helps explain why significant gains in responsible behavior were observed in the PBL group, while changes across the other environmental literacy components remained limited. Research in education for sustainable development further indicates that active, student-centered pedagogies such as PBL can effectively support behavioral development. By providing opportunities for students to engage with authentic environmental challenges and reflect on their personal responsibility, such approaches cultivate a stronger sense of agency and environmental stewardship (UNESCO, 2017). However, the mixed ANOVA results revealed that responsible environmental behavior increased over time in both groups, with no statistically significant difference between the PBL and Cambridge curriculum instruction groups. This pattern suggests that behavioral development may have been influenced by broader school experiences and growing environmental awareness rather than by the PBL intervention alone. As Stevenson et al. (2013) note, both conventional and exploratory learning

approaches contribute to the development of environmental knowledge, values, attitudes, and behavior through sustained instructional and experiential processes.

The modest between-group differences can be attributed to the substantial conceptual and pedagogical alignment between PBL and the Cambridge Lower Secondary Science curriculum. The Cambridge curriculum already foregrounds scientific thinking, practical skills, real-world application, and sustainability awareness – emphases that closely correspond with the central tenets of PBL, including collaborative inquiry, authentic problem-solving, and the active construction of knowledge. Consequently, the standard Cambridge curriculum instruction already incorporates many features known to foster environmental literacy. This synergy likely explains the relatively small incremental gains produced by the structured PBL intervention rather than large between-group differences. The findings therefore indicate that PBL functions not as a replacement for the Cambridge curriculum but as a complementary pedagogical enhancement that builds upon and extends its existing strengths.

5.2 Relationships Among Environmental Literacy Components

Environmental literacy is widely recognized as a multidimensional construct in which knowledge, attitudes, cognitive skills, and behavior are interrelated but do not always develop simultaneously (Hollweg et al., 2011). Previous research suggests that environmental knowledge does not necessarily lead directly to behavioral change, as pro-environmental behavior is influenced by a complex interaction of cognitive, affective, and contextual factors (Kollmuss & Agyeman, 2002; Negev et al., 2008).

Contemporary environmental literacy frameworks also emphasize that relationships among components are often indirect and develop over time, with knowledge and affect supporting the development of cognitive skills and behavior (Szczytko et al., 2019). Therefore, the absence of strong correlations among some environmental literacy components in the present study reflects the complex and gradual nature of environmental literacy development and is consistent with previous research (UNESCO, 2017).

The absence of strong correlations among several environmental literacy components in the present study may indicate that environmental literacy develops in complex and context-dependent ways. Multidimensional models of environmental literacy conceptualize knowledge, affect, cognitive skills, and behavior as interconnected yet distinct components, suggesting that improvements in one dimension may not necessarily coincide with simultaneous changes in others (Szczytko et al., 2019).

The present study was conducted in a private secondary school in Astana that implements the Cambridge curriculum. This curriculum explicitly aims to develop students who think scientifically, acquire practical skills alongside knowledge, and recognize that “science is for me,” while preparing them to address sustainability issues and environmental challenges. These goals align closely with the core features PBL. By embedding structured PBL scenarios within the existing Cambridge curriculum topics, the intervention demonstrated that PBL can serve as a natural extension of the Cambridge approach rather than a replacement, further strengthening students’ environmental literacy, particularly their environmentally responsible behavior.

Chapter 6: Conclusion

The purpose of this quasi-experimental study was to investigate the extent to which a Problem-Based Learning (PBL) intervention influences secondary school students' environmental literacy in one school in Astana, Kazakhstan. Environmental literacy was conceptualized as a multidimensional construct encompassing ecological knowledge, hope (as a proxy for affective dispositions), cognitive skills, and responsible environmental behavior (Hollweg et al., 2011; NAAEE, 2011; Szczytko et al., 2019). The study also examined relationships among these components following the PBL experience. Guided by established frameworks in environmental education (EE) and PBL (Hmelo-Silver, 2004; Savery, 2015), the research addressed a notable gap in empirical evidence on student-centered pedagogies for EE in post-Soviet Central Asian contexts, where Cambridge, teacher-directed methods predominate despite national policy commitments to sustainability and the SDGs.

6.1 Summary of the Study

This study examined the impact of a PBL intervention integrated into biology lessons on students' environmental literacy levels. A quasi-experimental design compared a treatment group exposed to PBL scenarios (focused on real-world biological and ecological problems, such as bioaccumulation, renewable/non-renewable resources, and health-environment links) with a control group receiving Cambridge instruction. Data were collected via pre- and post-intervention administration of an adapted environmental literacy instrument (Szczytko et al., 2019), measuring the four core components.

Quantitative analysis (paired t-tests, mixed ANOVA, ANCOVA, and Pearson/Spearman correlations) revealed selective rather than comprehensive effects. Responsible environmental behavior showed statistically significant improvement in the PBL group, suggesting that engagement with authentic, collaborative problem-solving fostered greater personal responsibility and action-oriented dispositions. Both groups exhibited gains in environmental knowledge over time (with the Cambridge group showing within-group significance), but no differential effect attributable to PBL. No significant

changes occurred in environmental hope or cognitive skills across time or between groups. Post-test total environmental literacy differences were largely explained by pre-existing baseline variations rather than the intervention. Correlation analysis in the PBL group identified a moderate positive relationship between knowledge and cognitive skills, while other inter-component associations (including those involving hope and behavior) were weak or non-significant.

These results partially align with broader EE literature, where PBL often enhances engagement, problem-solving, and behavioral intentions in environmental contexts (e.g., Basche et al., 2016; Gök & Boncukçu, 2023), yet full multidimensional gains in literacy frequently require longer or more intensive implementations. The findings highlight the gradual, context-dependent nature of environmental literacy development and the limitations of short-term interventions in shifting entrenched patterns of teaching and learning in Kazakhstan.

6.2 Strengths of the Study

Key strengths include the adoption of a quasi-experimental pre-post design with a control group, enabling causal inferences about the PBL intervention's effects while controlling for time-related changes. The use of a psychometrically validated instrument (Szczytko et al., 2019) provided a theoretically grounded, multidimensional assessment of environmental literacy suitable for adolescents. The intervention was contextually relevant, linking PBL scenarios to the Kazakhstani curriculum (e.g., biology topics) and local issues (e.g., pollution, resource use), enhancing ecological validity. By focusing on a Central Asian secondary school setting, the study contributes original empirical evidence to a region where sustainability education faces implementation gaps despite strong policy frameworks (e.g., Environmental Code, Carbon Neutrality Strategy by 2060).

6.3 Limitations of the Study

Several limitations must be acknowledged. The intervention duration was relatively short (six weeks across biology units), potentially insufficient for deep transformation across all literacy components, especially affective (hope) and higher-order cognitive domains. The single-school sample

in Astana limits generalizability to other Kazakhstani regions, school types, or socioeconomic contexts. Furthermore, the number of participants was insufficient for robust statistical analysis. Quasi-experimental design, while practical, could not fully randomize participants, leading to baseline group differences that complicated interpretation (though controlled via ANCOVA). Self-report measures for behavior and hope may be susceptible to social desirability bias. Finally, the study did not incorporate qualitative data (e.g., student reflections or observations), limiting insights into implementation processes, student experiences, or mediating factors (e.g., teacher facilitation quality, group dynamics).

6.4 Implications for Research, Practice, and Policy

The findings suggest PBL holds promise for fostering responsible environmental behavior, a critical yet challenging outcome in EE, through authentic, student-centered engagement. This supports gradual integration of PBL into Kazakhstani biology and natural science curricula to align with SCES requirements and national sustainability goals. Teachers may benefit from targeted professional development on PBL facilitation, scenario design, and scaffolding for inquiry in resource-constrained settings.

Practically, schools could start with hybrid approaches (combining traditional knowledge transmission with targeted PBL modules) to build familiarity and reduce resistance. Policymakers should consider curriculum revisions emphasizing interdisciplinary, problem-oriented EE, alongside teacher training and resource allocation (e.g., materials for models, dioramas, field trips). The selective behavioral gains underscore that knowledge transmission alone is insufficient; active pedagogies bridging cognition and action are essential for meaningful literacy.

6.5 Recommendations

To maximize the effectiveness of PBL in developing students' environmental literacy, several practical measures are recommended. First, PBL exposure should be extended across multiple subjects, instructional units, and semesters. This longer and more sustained implementation would allow for the

cumulative development of environmental hope, cognitive skills, and lasting responsible environmental behavior among students.

Second, structured professional development programs should be provided for teachers, focusing on adapting PBL to large class sizes, tight time constraints, and locally relevant environmental issues, such as air quality problems in Astana and the legacy of the Aral Sea ecological disaster.

Third, school-wide or community-linked projects should be integrated into the curriculum. Such initiatives would help reinforce positive behavior change and strengthen students' sense of environmental hope by enabling them to observe tangible, real-world impacts of their efforts.

Additionally, it is important to develop culturally and contextually adapted environmental education (EE) resources and assessment tools specifically designed for Kazakhstani adolescents.

Finally, collaboration between schools, non-governmental organizations (NGOs), and universities should be actively encouraged to design and implement scalable pilot projects on PBL in environmental education. Such partnerships would facilitate broader adoption and ensure the long-term sustainability of these initiatives.

The implementation of these recommendations can support a more effective integration of student-centered pedagogies into Kazakhstani schools and contribute meaningfully to the country's national goals for sustainable development and environmental protection.

6.6 Directions for Future Research

Longitudinal studies tracking PBL effects over one or more academic years would clarify delayed or cumulative impacts on literacy components. Expanding to multiple schools/regions in Kazakhstan (urban/rural, public/private) and incorporating qualitative methods (interviews, observations, reflections) could reveal implementation barriers/enablers. Comparative research across post-Soviet or developing contexts would illuminate cultural adaptations of PBL in EE. Exploring moderators (e.g., prior nature exposure, gender, socioeconomic status) and refining instruments for local validity could strengthen measurement. Finally, intervention studies testing enhanced PBL variants (e.g.,

with community partnerships or technology) could identify optimal conditions for comprehensive literacy gains.

6.7 Personal Reflection

Conducting this research deepened my appreciation for the complexities of shifting from traditional to student-centered pedagogies in a context like Kazakhstan, where policy ambitions for sustainability meet practical classroom realities. I initially expected broader PBL effects across all literacy dimensions, influenced by global literature, but the findings taught me the importance of realistic expectations given intervention scope, cultural-educational norms, and the tool's ability to detect subtle changes. Analyzing the data required me to view the modest findings not as shortcomings, but as meaningful evidence that targeted improvements, particularly in responsible environmental behavior, can emerge relatively early in such interventions. This insight underscored the value of adopting more gradual, context-sensitive strategies for advancing environmental education reform. The entire process reinforced my commitment to evidence-based advocacy for learner-centered, active pedagogies that equip young people to engage effectively with the urgent environmental challenges facing both Kazakhstan and the global community.

References

- Ali, S. S. (2019). Problem based learning: A student-centered approach. *English Language Teaching*, 12(5), 73-78. <https://eric.ed.gov/?id=EJ1212283>
- Anderson, M. A., & Maxwell, N. (2018). *Baseline equivalence: What it is and why it is needed*. AmeriCorps by Mathematica.
- Aslan, A. (2021). Problem- based learning in live online classes: Learning achievement, problem-solving skill, communication skill, and interaction. *Computers and Education*, 171, 104237. <https://doi.org/10.1016/j.compedu.2021.104237>
- Assaraf, O. B.-Z., & Orion, N. (2005). Development of system thinking skills in the context of earth system education. *Journal of Research in Science Teaching*, 42(5), 518–560. <https://doi.org/10.1002/tea.20061>
- Awewomom, J., Dzeble, F., Takyi, Y.D. *et al.* (2024). Addressing global environmental pollution using environmental control techniques: a focus on environmental policy and preventive environmental management. *Discover Environment* (2), 8. <https://doi.org/10.1007/s44274-024-00033-5>
- Ayerbe-López, J., & Perales-Palacios, F. J. (2023). Evaluating a secondary education urban ecology project within the framework of a problem-based learning methodology. *Education Sciences*, 13(9), 915. <https://doi.org/10.3390/educsci13090915>
- Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. Springer Publishing Company.
- Basche, A., Genareo, V., Leshem, A., Kissell, A., & Pauley, J. (2016). Engaging middle school students through locally focused environmental science project-based learning. *Natural Sciences Education*, 45(1), 1–10. <https://doi.org/10.4195/nse2016.05.0012>

- Bhushan, S., Govinda, R., & Mangalagiri, A. (1990). *Environmental education handbook for educational planners*. NIEPA. <https://unesdoc.unesco.org/ark:/48223/pf0000133471>
- Bočková, S., Bohovic, R., Ph. D., Hrnčiar, M., Muroň, M., Chytrý, J., Skalský, M., Černochohá, M., Kalmykov, D. (2023). *Air pollution in Kazakhstan as seen from space: Fundamental analysis, focus on the Karaganda Region, and notes on Kazakhstan's broader impact on climate change*. Arnika. <https://arnika.org/en/publications/air-pollution-in-kazakhstan-as-seen-from-space>
- Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability*, 7(11), 15693-15717. <https://doi.org/10.3390/su71115693>
- Boncukçu, G., & Gok, G. (2023). A problem-based learning activity to learn about sustainable development. *Science Activities*, 60(4), 185–200. <https://doi.org/10.1080/00368121.2023.2258353>
- Boye, E. S., & Agyei, D. D. (2023). Effectiveness of problem-based learning strategy in improving teaching and learning of mathematics for pre-service teachers in Ghana. *Social Sciences & Humanities Open*, 7(1), 100453. <https://doi.org/10.1016/j.ssaho.2023.100453>
- Cambridge International Education. (n.d.). *Cambridge Lower Secondary science curriculum*. <https://www.cambridgeinternational.org/programmes-and-qualifications/cambridge-lower-secondary/curriculum/science/>
- Caravita, S., Valente, A., Luzi, D., Pace, P., Valanides, N., Khalil, I., Berthou, G., Kozan-Naumscu, A., Babes-Bolyai, Clemente, P., & Lirdhist. (2008). Construction and validation of textbook analysis grids for ecology and environmental education. *Science Education International*, 19(2), 97–116. <https://files.eric.ed.gov/fulltext/EJ890627.pdf>

- Casaló, L.V., & Escario, J.J. (2018). Heterogeneity in the association between environmental attitudes and pro-environmental behavior: a multilevel regression approach. *Journal of Cleaner Production*, 175, 155-163. <https://doi.org/10.1016/j.jclepro.2017.11.237>
- Casaló, L.V., Escario, J.J., & Rodriguez-Sanchez, C. (2019). Analyzing differences between different types of pro-environmental behaviors: Do attitude intensity and type of knowledge matter? *Resources, Conservation and Recycling*, 149, 56-64. <https://doi.org/10.1016/j.resconrec.2019.05.024>
- Chueh, H.-E., & Kao, C.-Y. (2024). Exploring the impact of integrating problem based learning and agile in the classroom on enhancing professional competence. *Heliyon*, 10(3), e24887. <https://doi.org/10.1016/j.heliyon.2024.e24887>
- Cincera, J., Kroufek, R., & Bogner, F. X. (2023). The perceived effect of environmental and sustainability education on environmental literacy of Czech teenagers. *Environmental Education Research*, 29(9), 1276–1293. <https://doi.org/10.1080/13504622.2022.2107618>
- Cofone, L., Sabato, M., Di Rosa, E., Colombo, C., & Paglione, L. (2024). Evaluating the environmental impact of anthropogenic activities on human health: A systematic review. *Urban Science*, 8(2), 49. <https://doi.org/10.3390/urbansci8020049>
- Cox, A. H., & Amador, J. A. (2025). Development and implementation of an applied, interdisciplinary problem-based learning course in environmental science. *Natural Sciences Education*, 54(2). <https://doi.org/10.1002/nse2.70036>
- Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Boston, MA: Pearson.
- Dagar, V., & Yadav, A. (2016). Constructivism: A paradigm for teaching and learning. *Arts and Social Science Journal*, 7(4), 1000200. <https://doi.org/10.4172/2151-6200.1000200>

- Das, S., Nandgaonkar, V., Eklarker, R., Balkhande, B. W., & Pande, S. D. (2024). Exploring the dynamics of PBL-based learning: A study on collaboration, reflection, engagement, critical thinking, and student success. In K. Barua, N. Radwan, V. Singh, & R. Figueiredo (Eds.), *Design and implementation of higher education learners' learning outcomes (HELLO)* (pp. 146-158). IGI Global Scientific Publishing. <https://doi.org/10.4018/978-1-6684-9472-1.ch009>
- Demssie, Y. N., Biemans, H. J. A., Wesselink, R., & Mulder, M. (2022). Fostering students' systems thinking competence for sustainability by using multiple real-world learning approaches. *Environmental Education Research*, 29(2), 261–286. <https://doi-org.ezproxy.nu.edu.kz/10.1080/13504622.2022.2141692>
- Dewey, J. (1938). *Experience and education*. Macmillan.
- Disinger, J. F. (1983). What research says: Environmental education's definitional problem. *School Science and Mathematics*, 85(1), p. 59. <https://eric.ed.gov/?id=EJ312591>
- Dolmans, D. H., De Grave, W., Wolfhagen, I.H., & van der Vleuten, C.P. (2005). Problem-based learning: future challenges for educational practice and research. *Medical Education*, 39(7), 732-41. <https://doi.org/10.1111/j.1365-2929.2005.02205.x>
- Eccles, J. S., & Roeser, R. W. (2011). Schools as developmental contexts during adolescence. *Journal of Research on Adolescence*, 21(1), 225–241. <https://doi.org/10.1111/j.1532-7795.2010.00725.x>
- Elder, M., & Grunewald, S. (2025). Insights from Agenda 21 for enhancing the implementation of the SDGs and shaping the post-2030 sustainable development agenda. *Earth System Governance*, (25), 100262. <https://doi.org/10.1016/j.esg.2025.100262>
- Erdem, C., Kaya, M., Tunç Toptaş, H., & Altunbaşak, İ. (2025). Problem-based learning and student outcomes in higher education: A second-order meta-analysis. *Studies in Higher Education*, 1–22. <https://doi.org/10.1080/03075079.2025.2498084>

- Fang, W., Hassan, A., & LePage, B. (2023). *The living environmental education. Sound science toward a cleaner, safer, and healthier future*. Springer. Singapore.
<https://link.springer.com/book/10.1007/978-981-19-4234-1>
- Field, A. (2018). *Discovering statistics using IBM SPSS statistics (5th ed.)*. Sage Publications.
- Finger, M. (1994). From knowledge to action? Exploring the relationships between environmental experiences, learning, and behavior. *Journal of Social Issues*, 50(3), 141–160. <https://doi-org.ezproxy.nu.edu.kz/10.1111/j.1540-4560.1994.tb02424.x>
- Flamm, B. (2009). The impacts of environmental knowledge and attitudes on vehicle ownership and use. *Transportation Research Part D: Transport and Environment*, 14(4), 272-279.
<https://doi.org/10.1016/j.trd.2009.02.003>
- Frick, J., Kaiser, F.G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, 37(8), 597-1613. <https://doi.org/10.1016/j.paid.2004.02.015>
- Garner, J. K., Kuhn, M., Rocchio, A. M., & Friedenreich, G. (2025). Learning and belonging in a museum-school environmental stewardship partnership. *Journal of STEM Outreach*, 8(1), 1–13. <https://doi.org/10.15695/jstem/v8i1.02>
- George, D., & Mallery, P. (2019). *IBM SPSS statistics 26 step by step: A simple guide and reference (16th ed.)*. Routledge.
- Gibson, L., Stevenson, K., Busch, K. C., Cutts, B., Seekamp, E., & Krementz, S. (2024). Pushing toward systemic change in the Capitalocene: Investigating the efficacy of existing behavior prediction models on individual and collective pro-environmental actions in high school students. *The Journal of Environmental Education*, 55(2), 102–124.
<https://doi.org/10.1080/00958964.2023.2259853>

- Gibson, L., Stevenson, K., Busch, K. C., Cutts, B., Seekamp, E., & Krementz, S. (2026). Social capital as a predictor of collective environmental action in high school students. *The Journal of Environmental Education*, 57(1), 29–54. <https://doi.org/10.1080/00958964.2025.2525105>
- Gijbels, D., Dochy, F., Van den Bossche, P., & Mien, S. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research*, 75(1), 27-61. <https://doi-org.ezproxy.nu.edu.kz/10.3102/00346543075001027>
- Gök, G., & Boncukçu, G. (2023). The effect of problem-based learning on middle school students' environmental literacy and problem-solving skills. *Journal of Science Learning*, 6(4), 414–423. <https://doi.org/10.17509/jsl.v6i4.62781>
- Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research unresponsive environmental behavior: A meta-analysis. *The Journal of Environmental Education*, 18(2), 1–8. <https://doi.org/10.1080/00958964.1987.9943482>
- Hmelo-Silver, C.E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review* 16, 235–266. <https://doi.org/10.1023/B:EDPR.0000034022.16470.f3>
- Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., & Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. Washington DC: North American Association for Environmental Education. <https://cdn.naaee.org/sites/default/files/inline-files/devframeworkassessenvlitonlineed.pdf>
- Hopkins, C. (2012). Twenty years of education for sustainable development. *Journal of Education for Sustainable Development*, 6(1), 1–4. <https://doi.org/10.1177/097340821100600101>
- Hungerford, H., & Volk, T. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 2(3), 8-22. <https://doi.org/10.1080/00958964.1990.10753743>

International Trade Administration. (2022, September 2). *Mining equipment and services*.

U.S. Department of Commerce. <https://www.trade.gov/country-commercial-guides/kazakhstan-mining-equipment-and-services>

IUCN (1970). *International working meeting on environmental education in the school curriculum*.

Final report. Carson City, NV: IUCN.

<https://portals.iucn.org/library/sites/library/files/documents/Rep-1970-001.pdf>

Jang, E. Y., Park, H. S., & Jeong, Y. S. (2019). Using problem-based learning in a Chinese character class design: A case study of Korean learners of Chinese. *Journal of Chinese Writing Systems*, 3(2), 129-138. <https://doi-org.ezproxy.nu.edu.kz/10.1177/2513850219826745>

Jdaitawi, M. (2020). The effect of using problem-based learning upon students' emotions towards learning and levels of communication skills in three different disciplines. *Croatian Journal of Education*, 22(1), 207-240. <https://doi.org/10.15516/cje.v22i1.3215>

Johnson, B., & Christensen, L. (2020). *Educational research* (7th ed.). SAGE Publications, Inc.

Kabysheva, M. (2025). Fostering critical thinking in learning outcomes of Kazakhstan initial teacher education. *Frontiers in Education*, 10, 1554713. <https://doi.org/10.3389/feduc.2025.1554713>

Kaiser, F. G., Wölfling, S., & Fuhrer, U. (1999). Environmental attitude and ecological behaviour. *Journal of Environmental Psychology*, 19(1), 1–19. <https://doi.org/10.1006/jevp.1998.0107>

Kassembekova, A. (2020). *Humanities teachers' conceptualization and pedagogical practices of critical thinking: A qualitative case study within a Nazarbayev Intellectual School (NIS) in Kazakhstan* (Master's thesis, Nazarbayev University Graduate School of Education). <http://nur.nu.edu.kz/handle/123456789/4958>

- Khasanova, A., Syzdykova, L., Adylbek kyzy, G., & Karabalaeva, G. (2025). Transforming didactic methods: A new vision for Kazakhstan's primary education system. *Education as Change*, 29, Article 16658. <https://doi.org/10.25159/1947-9417/16658>
- Koçoğlu, A., & Kanadlı, S. (2025). The effect of problem-based learning approach on learning outcomes: A second-order meta-analysis study. *Educational Research Review*, 48, 100690. <https://doi.org/10.1016/j.edurev.2025.100690>
- Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3), 239–260. <https://doi.org/10.1080/13504620220145401>
- Kuvac, M., & Koc, I. (2019). The effect of problem-based learning on the environmental attitudes of preservice science teachers. *Educational Studies*, 45(1), 72–94. <https://doi.org/10.1080/03055698.2018.1443795>
- Laroche, M., Tomiuk, M. A., Bergeron, J., & Barbaro-Forleo, G. (2002). Cultural differences in environmental knowledge, attitudes, and behaviors of Canadian consumers. *Canadian Journal of Administrative Sciences*, 19, 267-282. <https://doi.org/10.1111/j.1936-4490.2002.tb00272.x>
- Law of the Republic of Kazakhstan. (2007, January 9). *Environmental Code of the Republic of Kazakhstan* (No. 212) [Section 7, Art. 183]. Unofficial translation. <https://adilet.zan.kz/eng/docs/K070000212>
- Lee, J. S., & Son, H. K. (2024). The effects of problem-based learning integrated with the nursing process on clinical reasoning, communication skills attitude and nursing process competency among nursing students: A quasi-experimental study. *Nurse Education in Practice*, 81, 104131. <https://doi.org/10.1016/j.nepr.2024.104131>

- Lee, T., Markowitz, E., Howe, P. D., Ko, C., Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*, 5, 1014–1020.
<https://doi.org/10.1038/nclimate2728>
- Li, C., & Monroe, M. C. (2018). Development and validation of the climate change Hope Scale for high school students. *Environment and Behavior*, 50(4), 454–479.
<https://doi.org/10.1177/0013916517708325>
- Liu, M., Shi, Y., Pan, Z., Li, C., Pan, X., & Lopez, F. (2020). Examining middle school teachers' implementation of a technology-enriched problem-based learning program: Motivational factors, challenges, and strategies. *Journal of Research on Technology in Education*, 53(3), 279–295.
<https://doi-org.ezproxy.nu.edu.kz/10.1080/15391523.2020.1768183>
- Liu, P., Teng, M., & Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors? The mediating role of environmental attitudes and behavioral intentions. *Science of The Total Environment*, 728, 138126.
<https://doi.org/10.1016/j.scitotenv.2020.138126>
- Lovren, V. O., & Jablanovic, M. M. (2023). Bridging the gap: The affective dimension of learning outcomes in environmental primary and secondary education. *Sustainability*, 15(8), 6370.
<https://doi.org/10.3390/su15086370>
- Maclean, R., & Pavlova, M. (2017). What type of pedagogy is required in schools and classrooms to support sustainable green growth? In R. Maclean (Ed.), *Life in schools and classrooms: Education in the Asia-Pacific region—Issues, concerns and prospects* (pp. 101–119). Springer.
https://doi.org/10.1007/978-981-10-3654-5_7
- Mcbeth, B., Hungerford, H. H., Marcinkowski, T., Volk, T., & Meers, R. (2008). *National environmental literacy assessment project: Year 1, national baseline study of middle grades*

students final research report. North American Association for Environmental Education. U.S.
https://www.noaa.gov/sites/default/files/legacy/document/2019/Jun/Final_NELA_minus_MSEL_S_8-12-08.pdf?utm_source=chatgpt.com

McBride, B. B., Brewer, C. A., Berkowitz, A. R., & Borrie, W. T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here? *Ecosphere* 4(5), 67.
<http://dx.doi.org/10.1890/ES13-00075.1>

Merriam-Webster. (n.d.). Literacy. In *Merriam-Webster.com dictionary*. <https://www.merriam-webster.com/dictionary/literacy>

Minister of Education and Science of the Republic of Kazakhstan. (2018). *On approval of state compulsory educational standards for all levels of education*.
<https://adilet.zan.kz/rus/docs/V1800017669>

Ministry of Ecology and Natural Resources of the Republic of Kazakhstan. (2023). *Updated nationally determined contribution of the Republic of Kazakhstan to the global response to climate change*. Astana. https://unfccc.int/sites/default/files/NDC/2023-06/12updated%20NDC%20KAZ_Gov%20Decree313_19042023_en_cover%20page.pdf

Mukhtarov, R., Ibragimova, O. P., Omarova, A., Tursumbayeva, M., Tursun, K., Muratuly, A., Karaca, F., & Baimatova, N. (2023). An episode-based assessment for the adverse effects of air mass trajectories on PM_{2.5} levels in Astana and Almaty, Kazakhstan. *Urban Climate*, 49, 101541.
<https://doi.org/10.1016/j.uclim.2023.101541>

NAAEE. (2011). *Developing a framework for assessing environmental literacy*. North American Association for Environmental Education.
<http://www.naaee.net/sites/default/files/framework/DevFramewkAssessEnvLitOnlineEd.pdf>.

- Naik, S. M., Bandi, S., & Reddy, C. L. (2024). Enhancing engineering education: exploring the impact of problem-based learning on freshman students' skills and engagement – a case study. *Journal of Engineering Education Transformations*, 38, 133–139.
<https://doi.org/10.16920/jeet/2024/v38is1/24222>
- Navarro, D. J., & Foxcroft, D. R. (2025). *Learning statistics with Jamovi: A tutorial for psychology students and other beginners*. Cambridge, UK: Open Book Publishers.
- Negev, M., Sagy, G., Garb, Y., Salzberg, A., & Tal, A. (2008). Evaluating the environmental literacy of Israeli elementary and high school students. *The Journal of Environmental Education*, 39(2), 3–20. <https://doi.org/10.3200/JOEE.39.2.3-20>
- Ningsih, T. Z., Aman, A., Nasrulloh, A., Ofianto, O., Erniwati, E., Asri, Z., Judijanto, J., & Firza, F. (2025). Enhancing communication and collaboration skills through discovery, cooperative and problem-based learning models in Social Studies education. *Cogent Education*, 12(1).
<https://doi.org/10.1080/2331186X.2025.2500110>
- O'Dwyer, L.M. & Bernauer, J.A. (2013). *Quantitative research for the qualitative researcher*. Sage Publications.
<https://doi.org/10.4135/9781506335674>
- OECD. (2019). *Programme for International Student Assessment (PISA): Results from PISA 2018 – Country note*. Kazakhstan.
https://www.oecd.org/content/dam/oecd/en/about/programmes/edu/pisa/publications/national-reports/pisa-2018/featured-country-specific-overviews/PISA2018_CN_KAZ.pdf
- OECD. (2024). *Diversifying Kazakhstan's exports: Institutions, policies, infrastructures*, OECD Publishing. Paris. <https://doi.org/10.1787/7f9cd8aa-en>.

- Olsson, D., & Gericke, N. (2016). The adolescent dip in students' sustainability consciousness- Implications for education for sustainable development. *The Journal of Environmental Education*, 47(1), 35–51. <https://doi.org/10.1080/00958964.2015.1075464>
- Ottenbreit-Leftwich, A., Kwon, K., Brush, T. A., Karlin, M., Jeon, M., Jantaraweragul, K., Guo, M., Nadir, H., Gok, F., & Bhattacharya, P. (2021). The impact of an issue-centered problem-based learning curriculum on 6th grade girls' understanding of and interest in computer science. *Computers and Education Open*, 2, 100057. <https://doi.org/10.1016/j.caeo.2021.100057>
- Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (7th edition.). Open University Press.
- Palmer, J. A. (1998). *Environmental education in the 21st century*. Routledge.
- Raath, S., & Golightly, A. (2017). Geography education students' experiences with a problem-based learning fieldwork activity. *Journal of Geography*, 116(5), 217–225. <https://doi.org/10.1080/00221341.2016.1264059>
- Roshayanti, F., Wicaksono, A., & Ipah, B. (2019). The effect of problem-based learning on students' environmental literacy. *Advances in Social Science, Education and Humanities Research*, 287, 250–254. <https://doi.org/10.2991/icesre-18.2019.44>
- Roth, C. E. (1992). *Environmental literacy: Its roots, evolution, and directions in the 1990s*. ERIC Clearinghouse for Science, Mathematics, and Environmental Education. <https://eric.ed.gov/?id=ED348235>
- Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *Lancet*, 379(9832), 2206–2211. [https://doi.org/10.1016/S0140-6736\(12\)60685-0](https://doi.org/10.1016/S0140-6736(12)60685-0)

- Salari, M., Roozbehi, A., Zarifi, A., & Tarmizi, R. A. (2018). Pure PBL, hybrid PBL and lecturing: Which one is more effective in developing cognitive skills of undergraduate students in pediatric nursing course. *BMC Medical Education*, 18(1), 195. <https://doi.org/10.1186/s12909-018-1305-0>
- Savery, J. R. (2015). Overview of problem-based Learning: Definitions and distinctions. Purdue University Press.
<https://doi.org/10.2307/j.ctt6wq6fh.6>
- Schahn, J., & Holzer, E. (1990). Studies of individual environmental concern: The role of knowledge, gender, and background variables. *Environment and Behavior*, 22(6), 767–786. <https://doi.org/10.1177/0013916590226003>
- Schmidt, H. G. (1983). Problem-based learning: Rationale and description. *Medical Education*, 17(1), 11-16.
<http://dx.doi.org/10.1111/j.1365-2923.1983.tb01086.x>
- Schmidt, H. G., & Moust, J. H. (2000). Factors affecting small-group tutorial learning: A review of research. In D. H. Evenson & C. E. Hlemono-Silver (Eds.) *Problem-based learning: A research perspective on learning interactions* (pp. 19–52). Lawrence Erlbaum.
<https://doi.org/10.4324/9781410604989-9>
- Seçgin, T., & Sungur, S. (2020). Investigating the science attitudes of students from low socioeconomic status families: The impact of problem-based learning. *Biochemistry and Molecular Biology Education*, 49(2), 228–235. <https://doi.org/10.1002/bmb.21447>
- Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing*, 16(1), 85–88.
<https://doi.org/10.1016/j.teln.2020.09.002>

- Snyder, C. R., Harris, C., Anderson, J. R., Holleran, S. A., Irving, L. M., Sigmon, S. T., Yoshinobu, L., Gibb, J., Langelle, C., & Harney, P. (1991). The will and the ways: Development and validation of an individual-differences measure of hope. *Journal of Personality and Social Psychology*, 60(4), 570–585. <https://doi.org/10.1037/0022-3514.60.4.570>
- Ssali, C., Kabuye Batiibwe, M. S., Dahl, B., Ampeire Kariisa, H., Magero, J. M., & Mayende, G. (2025). Problem-based learning in secondary school mathematics: A review. *Educational Research*, 67(2), 212–230. <https://doi-org.ezproxy.nu.edu.kz/10.1080/00131881.2025.2493255>
- Stapp, W. B. (1969). The concept of environmental education. *Journal of Environmental Education*, 1(1), 30–31. <https://eric.ed.gov/?id=EJ008946>
- Stevenson, R. B., Brody, M., Dillon, J., & Wals, A. E. J. (2013). *International handbook of research on environmental education*. Routledge. <https://doi.org/10.4324/9780203813331>
- Su, K.-D. (2024). The challenge and opportunities of STEM learning efficacy for living technology through a transdisciplinary problem-based learning activity. *Journal of Science Education and Technology*, 33(4), 429–443. <https://doi.org/10.1007/s10956-024-10094-z>
- Szczytko, R., Stevenson, K., Peterson, M. N., Nietfeld, J., & Strnad, R. L. (2019). Development and validation of the environmental literacy instrument for adolescents. *Environmental Education Research*, 25(2), 193–210. <https://doi.org/10.1080/13504622.2018.1487035>
- Ukaogo, P. O., Ewuzie, U., & Onwuka, C. V. (2020). Environmental pollution: causes, effects, and the remedies. *Microorganisms for Sustainable Environment and Health*, 419–429. <https://doi.org/10.1016/b978-0-12-819001-2.00021-8>
- UN. (1972). *Report of the United Nations conference on the human environment*. UN. Stockholm. <https://docs.un.org/en/A/CONF.48/14/Rev.1>

UNCED. (1992). *Agenda 21*. UN. Rio de Janeiro.

https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf?_gl=1*_xhjfe*_ga*MTA3MDE4NjM4MC4xNzYxMzU3Mjc*_ga_TK9BQL5X7Z*_czE3NjEzNTcyNzIkbzEkZzEkDD E3NjEzNTg3MTgkajQ1JGwwJGgw

UNEP. (1975). *The Belgrade charter: A framework for environmental education*. UNEP.

<https://unesdoc.unesco.org/ark:/48223/pf0000017772?posInSet=1&queryId=c785953a-52ed-4c89-939b-5b4c23e67008>

UNESCO MGIEP. (2017). *Textbooks for sustainable development: A guide to embedding*. Mahatma Gandhi Institute of Education for Peace and Sustainable Development.

<https://unesdoc.unesco.org/ark:/48223/pf0000259932>

UNESCO, & UNEP. (1977). *Tbilisi declaration: Intergovernmental conference on environmental education*. UNESCO. UNEP. <https://unesdoc.unesco.org/ark:/48223/pf0000032763>

UNESCO. (1968). *Intergovernmental conference of experts on the scientific basis for rational use and conservation of the resources of the biosphere*. UNESCO.

<https://files.eric.ed.gov/fulltext/ED047952.pdf>

UNESCO. (2017). *Education for sustainable development goals: Learning objectives*. UNESCO Publishing. <https://doi.org/10.54675/CGBA9153>

UNESCO. (2020). *Education for sustainable development: A roadmap*. UNESCO.

<https://doi.org/10.54675/YFRE1448>

UNESCO. (2025). *Education for sustainable development country profile: Kazakhstan*. UNESCO.

<https://unesdoc.unesco.org/ark:/48223/pf0000393406.locale=ru>

- Vygotsky, L. S. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.
- Wahelo, T. T., Mengistu, D. A., & Merawi, T. M. (2025). Geography teachers' implementation of problem-based learning for deforestation and climate change education in Metekel Zone secondary schools, Northwest Ethiopia. *International Journal of Educational Development*, 117, 103314. <https://doi.org/10.1016/j.ijedudev.2025.103314>
- Wood, D.F. (2003) ABC of learning and teaching in medicine: Problem-based learning. *British Medical Journal*, 326, 8. <http://dx.doi.org/10.1136/bmj.326.7384.328>
- World Bank. (2019). *Country partnership framework for the Republic of Kazakhstan 2020-2025*. World Bank Group. <https://www.worldbank.org/en/country/kazakhstan/publication/cpf-2020-2025>
- Yeung, S. (2010). Problem-based learning for promoting student learning in high school geography. *Journal of Geography*, 109(5), 190–200. <https://doi.org/10.1080/00221341.2010.501112>
- Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education*, 2(2), 75–79. <http://dx.doi.org/10.1016/j.hpe.2016.01.004>
- Zheng, K., Tan, L., Sun, Y., Wu, Y., Duan, Z., Xu, Y., & Gao, C. (2021). Impacts of climate change and anthropogenic activities on vegetation change: Evidence from typical areas in China. *Ecological Indicators*, 126, 107648. <https://doi.org/10.1016/j.ecolind.2021.107648>
- Zhou, Z. (2018). An empirical study on the influence of PBL teaching model on college students' critical thinking ability. *English Language Teaching*, 11(4), 15-20. <http://doi.org/10.5539/elt.v11n4p15>

Appendix A: AI Declaration Form



Thesis Title:

Declaration of the Use of Generative AI

I hereby declare that I have read and understood NUGSE's policy concerning appropriate use of AI and composed this work independently (please check one):

- ☐ with the use of artificial intelligence tools, or
- ☐ without the use of artificial intelligence tools.

(If you have used AI tools as defined in the GSE policy document, please complete the rest of this form.)

During the preparation of this thesis/examination, I used ChatGPT to brainstorm ideas, paraphrase, get feedback, structure and organize the written text.

I also declare that I

- ☐ am aware of the capabilities and limitations of AI tool(s),
- ☐ have verified that the content generated by AI systems and adopted by me is factually correct,
- ☐ am aware that as the author of this thesis I bear full responsibility for the statements and assertions made in it,
- ☐ have submitted complete and accurate information about my use of AI tools in this work, and
- ☐ acknowledge that there may be disciplinary consequences if I have not followed NUGSE's guidelines regarding appropriate AI use.

Name: Ayash Yelamanova

Date: 26.04.2026

Signature:

Appendix B: Intervention Plan

Week	Date	Lesson Topic	Learning Objectives	PBL Scenario	Duration (12h)
1	28.09.2025 — 31.10.2025	Pre-survey			1
2	3.11.2025 — 7.11.2025	A balanced diet	8Bp.02 Understand that carbohydrates and fats can be used as a store of energy in animals, and animals consume food to obtain energy and nutrients.	You are a wildlife nutritionist designing a "cafeteria" menu for animals in a local zoo to ensure they get the right balance of carbohydrates and fats for energy storage and daily needs. Research how different animals (like bears, birds, and squirrels) consume food in the wild, and create a model menu using everyday items to represent carbs (e.g., fruits, grains) and fats (e.g., nuts, seeds). Build a diorama of the cafeteria, explain how these nutrients	1

				provide energy, and present how an unbalanced diet could affect the animals' health and survival in their ecosystems. Tie this to environmental literacy by discussing how habitat changes (like deforestation) impact food availability for animals.	
	3.11.2025 – 7.11.2025	Growth, development and health	8Bp.03 Discuss how human growth, development and health can be affected by lifestyle in particular diet.	As a health ambassador for your school, create a community campaign to promote balanced diets for teens. Survey classmates about their eating habits, research how poor diets (e.g., too much junk food) affect growth, bone development, and overall health during adolescence. Design a recipe book showing nutritious meals that support energy needs and prevent	1

				issues like obesity. Connect to environmental literacy by exploring how access to fresh foods is linked to local farming and pollution's effect on crop quality, and propose ways to improve school lunches using sustainable sources.	
3	10.11.2025 – 14.11.2025	Growth, development and health	8Bp.03 Discuss how human growth, development and health can be affected by lifestyle in particular smoking.	You are part of a teen advocacy group creating an anti-smoking program for middle schoolers. Investigate how smoking impacts lung development, growth stunting, and long-term health risks like heart disease during adolescence. Develop interactive materials like a app prototype that simulates lifestyle choices and their effects. Present your project to the class, including data on how	1

				secondhand smoke affects non-smokers. Link to environmental literacy by discussing air pollution from tobacco farming and waste, and suggest eco-friendly alternatives like community clean-air initiatives.	
	10.11.2025 – 14.11.2025	Structure of blood and its function	8Bs.02 Describe the components of blood and their functions: red blood cells transporting oxygen, white blood cells protecting against pathogens, plasma transporting blood cells, nutrients and carbon dioxide.	Imagine you're a scientist engineering a "super blood" model to help astronauts survive in space. Build a 3D model or animation showing blood components—red cells for oxygen transport, white cells for fighting infections, and plasma for carrying nutrients and waste. Research how blood functions change in low-oxygen environments like high altitudes or polluted areas. Test your model	1

				with simple experiments (e.g., using colored water to represent components). Relate to environmental literacy by exploring how water pollution or deforestation reduces oxygen in ecosystems, affecting animal blood functions and human health.	
4	17.11.2025 - 21.11.2025	Joints and muscles	8Bs.01 Identify ball-and-socket and hinge joints. 8Bs.01 Explain how antagonistic muscles move the bones at a hinge joint.	As inventors for a robotics company, design prosthetic limbs for animals injured in wildlife accidents. Identify and label ball-and-socket (e.g., hip) and hinge joints (e.g., knee) in human and animal skeletons using diagrams or clay models. Create a prototype robot arm or leg that mimics these joints for smooth movement. Present how	1

				these joints enable daily activities. Connect to environmental literacy by discussing how habitat destruction leads to more animal injuries and propose conservation projects to protect natural movement spaces.	
	17.11.2025 - 21.11.2025	Bioaccumulation of toxic substances	8Be.02 Describe the impact of the bioaccumulation of toxic substances on an ecosystem.	As environmental detectives, investigate a mystery illness in a river ecosystem caused by bioaccumulation (e.g., pesticides building up in fish and birds). Create a food chain model showing how toxins accumulate from plants to top predators. Use maps or simulations to track pollution sources like farms or factories. Propose solutions like cleaner farming practices.	1

				Present findings in a report or skit. Directly link to the environmental literacy survey by referencing algae blooms and phosphates, showing how toxins reduce oxygen and harm populations.	
5	24.11.2025 — 28.11.2025	Unit exam			1
	24.11.2025 — 28.11.2025	Renewable resources	8ESp.02 Identify renewable resources (including wind, tidal and solar power, and bioplastics) and describe how humans use them.	A coastal town faces overfishing and erosion due to declining renewable resources like wind and tidal energy. Students identify renewables (wind, tidal, solar, bioplastics, 8ESp.02), describe their environmental benefits, interpret data from a local energy study (8TwSa.03), and design a sustainable resource plan to	1

				restore the ecosystem.	
6	1.12.2025 — 5.12.2025	Non-renewable resources	8ESp.02 Identify non-renewable resources (including fossil fuels) and describe how humans use them.	A mining region experiences soil degradation and water pollution from coal extraction. Students identify non-renewables (fossil fuels, 8ESp.02), describe environmental impacts, interpret depletion data (8TwSa.03), and propose a reclamation plan (e.g., reforestation), noting conclusion limitations.	1
	1.12.2025 — 5.12.2025	Unit Exam			1
7	8.12.2025 — 12.12.2025	Post-survey Reflection			1

Appendix C: Consent Letters

Informed Consent Form for Parents and Guardians

Introduction.

Dear Parent/Guardian,

Your child is invited to participate in a research study entitled Developing Students' Environmental Literacy Through Problem-Based Learning in One Secondary School in Astana conducted by Nazarbayev University. This form provides details about the study, including its purpose, procedures, risks, benefits, and your rights as a parent/guardian. Please read carefully and decide whether to allow your child to participate. This form is available in English, Russian, and Kazakh to accommodate your preferred language.

Procedures.

The study aims to determine whether PBL, a teaching method involving collaborative problem-solving, enhances students' environmental literacy compared to traditional instruction. It will also explore how the four components of environmental literacy (knowledge, hope, cognitive skills, behaviors) interact and contribute to environmentally responsible behavior.

Duration: The study will run from October 28, 2025, to December 12, 2025 (6 weeks), during regular biology lessons.

Pre-Survey (October 28, 2025): Your child will complete a 15–20-minute online survey via Qualtrics to measure their environmental literacy. The survey is anonymous, using a unique, randomly generated study code, and is available in English, Russian, or Kazakh. No personal identifiers will be collected.

Instructional Phase (November 3–December 11, 2025):

Students will work in small groups (4–5 students) on environmental problem-solving activities aligned with the biology curriculum, following PBL principles.

Schedule: Activities will occur during regular 40-minute biology lessons (two per week, ~12 lessons total), with no additional time commitment outside class.

Post-Survey (December 12, 2025): Your child will complete the same 15–20-minute survey, using their unique study code to match pre- and post-survey responses.

Student Assent: Your child has been provided with a printed assent form along with this parental consent form. The assent form, written in age-appropriate language, explains the study and asks your child to confirm their willingness to participate by signing it. Both forms have been sent home with your child for your review and completion. Please ensure your child signs the assent form and you sign this consent form, and return both to the school by October 24, 2025.

Total Survey Time: Approximately 30–40 minutes for surveys (pre- and post); all other activities occur within regular class time.

Risks.

The potential risks of participating in this study are:

Psychological: Your child may experience mild stress or discomfort while answering survey questions or participating in PBL group activities, particularly if they are unfamiliar with collaborative tasks or feel uncertain about environmental topics.

Social: During PBL group discussions, some students may feel self-conscious or face peer judgment, especially if they are less confident in expressing ideas.

Mitigation: Teachers will be trained to supervise activities, foster a supportive classroom environment, and ensure equitable participation. A school counselor will be available if your child experiences stress or discomfort. Clear instructions will be provided to minimize anxiety.

Benefits.

This study will contribute to environmental education research by providing empirical evidence on the effectiveness of PBL in enhancing students' environmental literacy in Kazakhstan.

For Nazarbayev University, it will strengthen the institution's research portfolio and support future scholarly outputs.

For the scientific community, it offers context-specific insights from a region with limited existing data.

For participants, potential benefits include increased environmental awareness, improved problem-solving skills, and greater engagement with sustainability issues.

Compensation. No tangible compensation will be given. A summary of the research results will be shared with the school administration and made available to students and parents through a brief written report. This summary will present aggregated, anonymized findings so that no individual participant can be identified.

Confidentiality & Privacy.

Any information that is obtained during this study will be kept confidential to the full extent possible. All efforts, within reason, will be made to keep your child personal information in your research record confidential but total confidentiality cannot be guaranteed.

Anonymity: No personal identifiers will be collected. Your child will use a unique study code for surveys to ensure anonymity and allow pre- and post-survey matching.

Data Security: All data will be stored electronically on a password-protected laptop with an encrypted cloud backup, accessible only to the Principal Investigator. No physical copies will be created.

Risk Mitigation: Students will be instructed to keep their study codes private to prevent sharing with peers, which could affect data matching.

Data Retention: All data will be securely deleted within three years of the final research report (expected by June 2028).

Limitations: While every effort will be made to protect confidentiality, total confidentiality cannot be guaranteed if students share their study codes with others.

Voluntary Nature of the Study. Participation in this study is strictly voluntary, and if agreement to participation is given, it can be withdrawn at any time without prejudice.

Points of Contact. It is understood that should any questions or comments arise regarding this project, or a research related injury is received, the Principal Investigator, Ayash Yelamanova, +77477755195, ayash.yelamanova@nu.edu.kz should be contacted. Any other questions or concerns may be addressed to the Nazarbayev University Institutional Research Ethics Committee, resethics@nu.edu.kz.

Statement of Consent.

I have read and understood this parental consent form. I agree to allow my child to participate in the research study described above. I understand that participation is voluntary, and I or my child may withdraw at any time without prejudice. I acknowledge that this form is being provided in my preferred language (English, Russian, or Kazakh) or that I have requested a translation if needed. I confirm that I have received and reviewed the student assent form provided to my child.

SIGNATURE OF PERSON OBTAINING

Only students with signed parental consent and their own assent will participate.

Name of Person Obtaining Consent

Contact Number

Signature of Person Obtaining

Date

Consent

If you wish to ask questions about your rights as a research participant or if you wish to voice any problems or concerns you may have about the study to someone other than the researchers, please write an email to NU IREC at resethics@nu.edu.kz

Appendix D: Recruitment Emails

RECRUITMENT LETTER FOR PARTICIPATION IN RESEARCH

Research Title: Developing Environmental Literacy Through Problem-Based Learning in One Secondary School in Astana

Researcher Information: Ayash Yelamanova, Master’s Student, Nazarbayev University. Email: ayash.yelamanova@nu.edu.kz

Dear [Name],

My names is Ayash Yelamanova, a Master’s student in Educational Leadership at Nazarbayev University. I am writing to seek your permission to conduct a research study at Quantum TECH School for my thesis, titled “Developing Students’ Environmental Literacy through Problem-Based Learning in One Secondary School in Astana.” The study aims to explore how problem-based learning (PBL) can enhance students’ environmental literacy within the biology curriculum. The study will involve approximately 80 Grade 7 students and will take place over six weeks (October 28 – December 9, 2025). It will consist of lessons integrating PBL activities, with data collected through pre- and post-surveys. Key details include:

Voluntary Participation: Student participation is entirely voluntary, with informed consent from parents and assent from students required prior to involvement.

Confidentiality: All data will be anonymized, ensuring no student names or identifying details appear in reports or publications.

Minimal Disruption: The intervention will be seamlessly integrated into regular biology lessons to avoid disruption to the school schedule.

The study adheres to the ethical research standards of Nazarbayev University, ensuring participant safety and confidentiality. Your approval and support would greatly contribute to advancing research on innovative teaching practices in Kazakhstan and provide valuable insights for enhancing science education.

If you have any questions or need further details, please feel free to contact me at ayash.yelamanova@nu.edu.kz or +77477755195. I would be happy to discuss the study further or provide additional documentation as needed.

Thank you for considering this request. I sincerely appreciate your time and look forward to your favorable response.

Best regards,

Ayash Yelamanova

Master's Student, Educational Leadership

Nazarbayev University

Graduate School of Education

Mob. Tel: +77477755195

E-mail: ayash.yelamanova@nu.edu.kz

Appendix E: Data Collection Instruments

Environmental Literacy Instrument for Adolescents

PART ONE: ECOLOGICAL KNOWLEDGE

Please choose the best answer for the following questions.

1. Phosphates are harmful in rivers because they:

- A. cause cancer in fish
- B. stop reproduction in fish
- C. make the water cloudy by reflecting sunlight
- D. cause algae blooms that reduce oxygen in the water

2. Ecology is the study of the relationship between:

- A. different species of animals
- B. plants and the atmosphere
- C. organisms and their environments
- D. people and other animals

3. A series of predictable changes that occur in a community over time is called _____.

- A. succession
- B. climax community
- C. ecosystem
- D. pioneer species

4. There are 150 longleaf pine trees per square kilometer in a certain area of the NC Sandhills. To which population characteristic does this information refer?

- A. growth rate
- B. geographic range
- C. age structure
- D. population density

5. What is the original source of energy for all living things on the earth's surface?

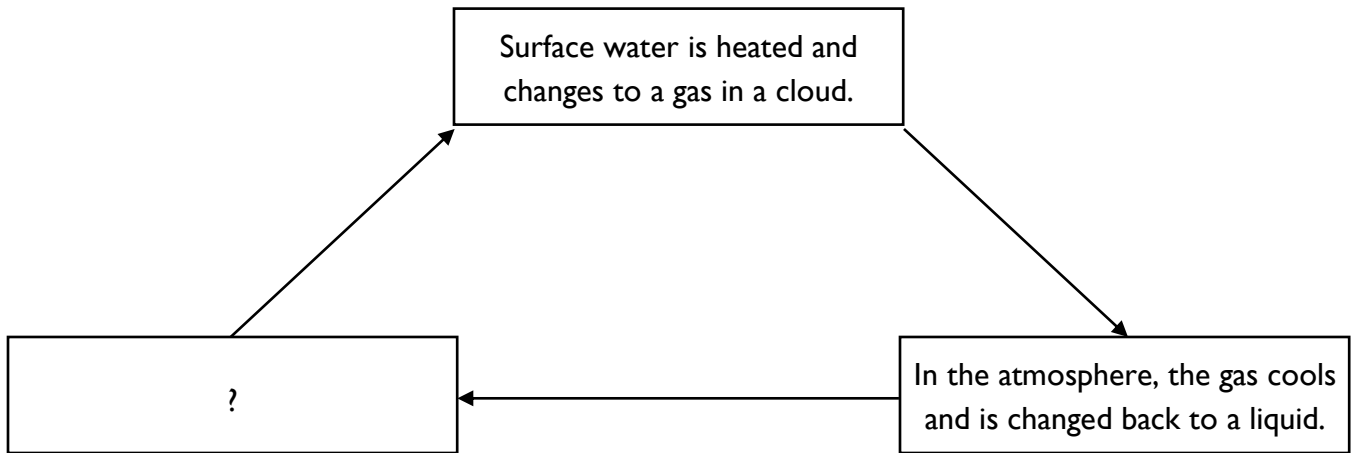
- A. the sun
- B. water
- C. the soil
- D. plants

6. What do you call all living organisms and nonliving parts of their environment?

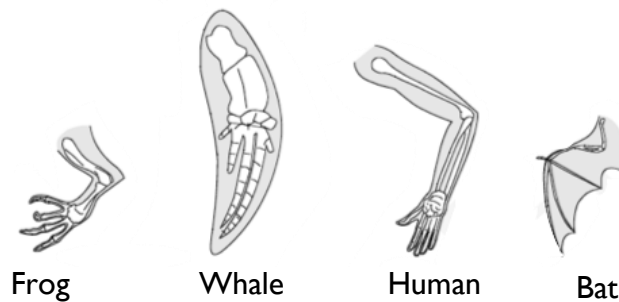
- A. the biosphere
- B. the environment
- C. an ecosystem
- D. a community

7. Which process is missing in the blanks below?

- A. the water falls from atmosphere as rain, ice, or snow
- B. the liquid freezes and becomes ice
- C. the sun dries up the water in the clouds
- D. the water stays in the clouds



8. This diagram represents the bone structure of the front limbs of four different animals.



Based on the image above, which do you think is the best conclusion about these animals?

- A. they grow at the same rate
- B. they live in the same environment
- C. they live for the same length of time
- D. they evolved from a common ancestor

9. What important role do soil organisms such as worms, bacteria, and fungi play?

- A. storing moisture for plants to absorb
- B. recycling the remains of dead organisms
- C. creating oxygen for animals to use
- D. removing carbon from the soil

10. Mycorrhizae are fungi that live on or in tree roots. Trees provide sugars to the fungi and the fungi transfer essential minerals from decaying organic matter to the plant. Which type of symbiotic relationship does this best illustrate?

- A. commensalism
- B. mutualism
- C. parasitism
- D. predation

PART TWO: ENVIRONMENTAL HOPE

Please choose the best answer for the following questions.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I believe people will be able to solve most environmental problems.					
The actions I can take are too small to help solve most environmental problems.					
I believe scientists will be able to find ways to solve environmental problems.					
Even when some people give up, I know there will be people who will continue to try to solve environmental problems.					
Environmental problems are out of my control.					
Because people can learn from our mistakes, we will influence the environment in a positive direction.					
Every day, more people care about environmental problems.					
If everyone works together, we can solve environmental problems.					

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Environmental problems are so complex, we will never be able to solve them.					
I know that there are many things that I can do to help solve environmental problems.					
I feel helpless to solve environmental problems.					

PART THREE: COGNITIVE SKILLS

Next, you will read two short passages. Each will give you information about an environmental problem. After you read the passage, please rank the questions based on how important you think they are for addressing the problem.

Striped Bass

Striped bass is a popular sportfish and is also harvested for food. Anglers and commercial fishers are spending more time fishing for striped bass than they used to, but are catching fewer and smaller striped bass than in the past. Daniel Pinder is in charge of making sure that fishing for striped bass is sustainable over time. Therefore, Daniel must think about many issues to determine the best solution to this challenge.

What are the most important questions to ask as you begin to solve this problem?

Please rank each question from most important (1) to least important (5). Use each number (1-5) only once.

1. Most important question
2. Second most important question
3. Third most important question
4. Fourth most important question
5. Least important question

	Ranking
What do <u>striped bass</u> fishers use for bait?	
What have been the numbers of new <u>striped bass</u> entering the population each year?	
What are the most important foods <u>striped bass</u> eat?	

	Ranking
What size are the <u>striped bass</u> that can successful reproduce?	
Do predators eat juvenile <u>striped bass</u> ?	

PART FOUR: BEHAVIOR

How often do you do the following activities?

	Never	Rarely	Sometimes	Often	Always
Turn off the lights at home when they are not in use					
Pick up trash that I find outside					
Turn off the water when it is not in use					
Close the refrigerator door while I decide what to get out of it					
Recycle at home					

PART FIVE: ABOUT YOU

Tell us a little about yourself by selecting the appropriate response.

1. Which grade are you in currently?

- 9th grade
- 10th grade
- 11th grade
- 12th grade

2. What is your age today?

- 14 years or younger
- 15 years old
- 16 years old
- 17 years old
- 18 years or older

3. What is your gender identity?

- Female
- Non-binary
- Male
- My gender identity is not listed.

4. What is your race or ethnicity? (select all that apply)

- Asian/Pacific Islander
- Black or African American
- Hispanic or Latino

- Native American or Indigenous
- White or Caucasian
- My race/ethnicity is not listed