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IMPROVING THE METHODOLOGY OF TEACHING GLOBAL ISSUES AND SUSTAINABLE DEVELOPMENT TO 5–6 GRADE STUDENTS THROUGH THE ELECTIVE NATURAL SCIENCE COURSE “SCIENCE AROUND US”

Abstract

This article examines the effectiveness of an interdisciplinary elective course titled “Science Around Us” in enhancing middle school students’ understanding of global challenges and the principles of sustainable development. The course is designed to help learners recognize the interconnected nature of environmental, social, and scientific issues, while also fostering critical thinking and research skills essential for addressing real-world problems.

The course was implemented for Grade 5–6 students at Gymnasium No. 4 named after A.S. Pushkin in Almaty. Its curriculum integrates key topics from geography, chemistry, biology, and physics, presenting them through a problem-oriented and research-based learning approach. Students engaged in inquiry activities, discussions, and small research projects aimed at analyzing global challenges such as climate change, resource depletion, and environmental pollution.

To evaluate the course’s effectiveness, an initial baseline assessment of students’ knowledge was conducted at the beginning of the program. An intermediate assessment followed after the first and second academic term to measure learning progress. The results demonstrate a significant improvement in students’ understanding of sustainable development concepts and global issues. The mean test score increased substantially, rising from 47% at baseline to 81% after one term of instruction.

In addition to quantitative gains, qualitative observations revealed increased student engagement, curiosity, and confidence in discussing complex global problems. Learners demonstrated improved ability to analyze cause-and-effect relationships and propose potential solutions. The novelty of this study lies in its integrated curriculum design within a secondary school context and the systematic measurement of learning outcomes. Overall, the findings support the value of interdisciplinary, problem-based science education in developing young learners’ awareness of global challenges and essential skills for sustainable development.

Keywords: global challenges, sustainable development, interdisciplinary learning, research-based learning, critical thinking, middle school science, Education for Sustainable Development.

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«БІЗДІ ҚОРШАҒАН ҒЫЛЫМ» ЖАРАТЫЛЫСТАНУ БОЙЫНША ЭЛЕКТИВТІ КУРСЫ АРҚЫЛЫ 5–6-СЫНЫП ОҚУШЫЛАРЫНА ҒАЛАМДЫҚ МӘСЕЛЕЛЕР МЕН ТҰРАҚТЫ ДАМУДЫ ОҚЫТУ ӘДІСТЕМЕСІН ЖЕТІЛДІРУ

Аңдатпа

Бұл зерттеуде негізгі мектеп оқушыларының жаһандық сын-қатерлер мен тұрақты даму қағидаттары туралы түсінігін арттыруға бағытталған «Бізді қоршаған ғылым» атты пәнаралық элективті курстың тиімділігі қарастырылады. Курс оқушыларға экологиялық, әлеуметтік және ғылыми мәселелердің өзара байланысын түсінуге көмектесіп, нақты өмірлік мәселелерді шешуге қажетті сыни ойлау мен зерттеу дағдыларын дамыту мақсатында әзірленген.

Курс Алматы қаласындағы А. С. Пушкин атындағы №4 гимназияның 5–6 сынып оқушылары үшін енгізілді. Оның мазмұны география, химия, биология және физика пәндерінің негізгі тақырыптарын біріктіріп, проблемалық-бағдарлы және зерттеуге негізделген оқыту формасында ұсынылды. Оқушылар климаттың өзгеруі, табиғи ресурстардың сарқылуы және қоршаған ортаның ластануы сияқты жаһандық мәселелерді талдауға бағытталған зерттеу тапсырмаларын орындап, пікірталастар мен шағын жобаларға қатысты.

Курстың тиімділігін бағалау мақсатында оқу басталған кезде оқушылардың білім деңгейін анықтауға арналған бастапқы диагностика жүргізілді. Бірінші және екінші оқу тоқсаны аяқталғаннан кейін оқу жетістіктерінің динамикасын анықтау үшін аралық бағалау өткізілді. Нәтижелер оқушылардың тұрақты даму ұғымдары мен жаһандық мәселелерді түсіну деңгейінің айтарлықтай артқанын көрсетті. Орташа тест нәтижесі бастапқы кезеңдегі 47 %-дан бір тоқсаннан кейін 81 %-ға дейін өсті.

Сандық көрсеткіштермен қатар, сапалық бақылаулар оқушылардың оқу мотивациясының, танымдық белсенділігінің және күрделі жаһандық мәселелерді талқылаудағы сенімділігінің артқанын көрсетті. Оқушылар себеп-салдарлық байланыстарды талдау және ықтимал шешімдерді ұсыну дағдыларын жетілдірді. Бұл зерттеудің жаңашылдығы – орта мектеп жағдайында пәнаралық оқу курсының әзірленуі және оқу нәтижелерінің жүйелі түрде бағалануы. Жалпы алғанда, алынған нәтижелер пәнаралық, проблемалық-бағдарлы жаратылыстану білімінің оқушылардың жаһандық сын-қатерлерге саналы көзқарасын қалыптастыруда және тұрақты даму дағдыларын дамытуда маңыздылығын растайды.

Түйін сөздер: жаһандық мәселелер, тұрақты даму, пәнаралық оқыту, зерттеушілік оқыту, сыни ойлау, жаратылыстану білімі, тұрақты даму мүддесіне арналған білім.

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СОВЕРШЕНСТВОВАНИЕ МЕТОДИКИ ПРЕПОДАВАНИЯ ГЛОБАЛЬНЫХ ПРОБЛЕМ И УСТОЙЧИВОГО РАЗВИТИЯ У ОБУЧАЮЩИХСЯ 5-6 КЛАССОВ ЧЕРЕЗ ЭЛЕКТИВНЫЙ КУРС ПО ЕСТЕСТВОЗНАНИЮ «НАУКА ВОКРУГ НАС»

Аннотация

В статье рассматривается эффективность междисциплинарного элективного курса «Наука вокруг нас», направленного на повышение понимания учащимися основной школы глобальных вызовов и принципов устойчивого развития. Курс разработан с целью помочь школьникам осознать взаимосвязанный характер экологических, социальных и научных проблем, а также развить критическое мышление и исследовательские навыки, необходимые для решения реальных задач.

Курс был реализован для учащихся 5–6 классов гимназии № 4 имени А. С. Пушкина г. Алматы. Его содержание интегрирует ключевые темы географии, химии, биологии и физики, которые представлены в проблемно-ориентированном и исследовательском формате обучения. Учащиеся выполняли поисковые задания, участвовали в обсуждениях и мини-исследованиях, направленных на анализ глобальных вызовов, таких как изменение климата, истощение природных ресурсов и загрязнение окружающей среды.

Для оценки эффективности курса в начале обучения была проведена входная диагностика уровня знаний учащихся. После первой и второй четверти было проведено промежуточное оценивание с целью определения динамики обучения. Результаты показали значительное улучшение понимания учащимися концепций устойчивого развития и глобальных проблем. Средний показатель тестирования существенно вырос — с 47 % на начальном этапе до 81 % после одного триместра обучения.

Помимо количественных результатов, качественные наблюдения выявили повышение учебной мотивации, познавательной активности и уверенности учащихся при обсуждении сложных глобальных проблем. Школьники продемонстрировали улучшенные навыки анализа причинно-следственных связей и выдвижения возможных решений. Новизна данного исследования заключается в междисциплинарном дизайне учебного курса в условиях средней школы и систематической оценке образовательных результатов. В целом полученные выводы подтверждают ценность междисциплинарного, проблемно-ориентированного естественно-научного образования для формирования у учащихся осознанного отношения к глобальным вызовам и навыков устойчивого развития.

Ключевые слова: глобальные проблемы, устойчивое развитие, междисциплинарное обучение, исследовательское обучение, критическое мышление, естественнонаучное образование, образование в интересах устойчивого развития.

Introduction. Modern society faces complex global challenges – from climate change and biodiversity loss to public health crises – that require a scientifically literate and sustainability-minded population. Education is increasingly recognized as a pivotal instrument for equipping younger generations with the knowledge, skills, and values needed to address these 21st-century challenges [1]. In particular, Education for Sustainable Development (ESD) has emerged as a global educational priority, aiming to integrate principles of sustainable development into all levels of education. ESD cultivates learners' abilities to understand the environmental, social, and economic impacts of their actions and empowers them to act sustainably in complex real-life scenarios [1]. As UNESCO has emphasized, *"Education can, and must, contribute to a new vision of sustainable global development... Education has a responsibility to be in gear with 21st-century challenges and foster the right types of values and skills that will lead to sustainable and inclusive growth and peaceful living together"*. This

vision underscores the urgency of reorienting school curricula to address global challenges and sustainability.

Kazakhstan, in line with international efforts, has incorporated the United Nations Sustainable Development Goals (SDGs) into its national development strategies and is revising educational curricula to embed ESD principles [1]. Nevertheless, analyses of the Kazakhstani education system indicate that more emphasis is still needed on sustainability topics and on developing students' critical thinking and problem-solving skills for sustainable development [1]. Today's secondary school students will become tomorrow's decision-makers, so it is crucial that they not only acquire factual knowledge about global issues but also learn to think critically about complex, interdisciplinary problems. Integrating global challenges into the school curriculum – especially through an interdisciplinary approach – is seen as a way to make learning more relevant and to prepare students to engage with real-world issues [2]. Research in education suggests that fostering connections between subjects can yield a more holistic understanding and promote deeper cognitive skills. For example, interlinking learning across different subject areas helps students see patterns and relationships and *"promotes critical thinking, a vital skill in today's fast-paced world" [3]*. In other words, an interdisciplinary curriculum can encourage students to think deeply about big problems by applying multiple lenses, thus reflecting the interconnected nature of global challenges. This approach aligns with the educational philosophy of John Dewey and others who advocated learning through doing and connecting knowledge to real-life contexts [3].

Contemporary global challenges, including climate change, biodiversity loss, socio-economic inequality, and environmental crises, highlight the urgent need to develop students' systemic understanding of sustainable development principles. The United Nations *Sustainable Development Goals Report 2024* emphasizes that achieving the Sustainable Development Goals (SDGs) is directly linked to improving the quality of education and fostering environmental awareness and civic responsibility among learners (United Nations, 2024). In this context, education is viewed as a key instrument for societal transformation.

The conceptual foundations of Education for Sustainable Development (ESD) are outlined in UNESCO documents, which stress the transition from knowledge transmission to the development of competencies, critical thinking, and responsibility for the future (UNESCO, 2020; UNESCO, 2022). Within this framework, interdisciplinarity, practice-oriented learning, and active student engagement become particularly significant.

Research indicates that the implementation of sustainable development principles within national education systems faces several challenges, including insufficient methodological training of teachers and limited instructional resources (Yelubayeva et al., 2023). In the context of Kazakhstani education, improving methodologies for teaching global issues while considering students' age-specific characteristics remains a relevant task.

Inquiry-based learning is considered one of the most effective approaches to fostering systemic thinking and understanding of global processes. Pedaste et al. (2015) describe the phases of the inquiry cycle that support the development of students' cognitive engagement. The research synthesis conducted by Minner, Levy, and Century (2010) confirms the positive impact of inquiry-based science instruction on academic achievement and deeper conceptual understanding.

The development of critical thinking skills is essential in preparing students to address global challenges. The European School Education Platform (2025) highlights the importance of fostering analytical skills, information evaluation, and evidence-based decision-making. Hendricks (2023) notes that interdisciplinary learning and content integration significantly contribute to the development of critical thinking in middle school students.

In the context of science and geography education, the system-activity approach and practice-oriented learning formats are particularly relevant (Kumarbekuly et al., 2023). Recent studies also emphasize the role of digital educational resources and artificial intelligence technologies in enhancing instructional effectiveness (Kadirbayeva & Serikbayeva, 2023; Aitkozhina & Zhensikbayeva, 2025).

Basic provisions. Thus, the analysis of scholarly literature demonstrates that developing students' understanding of global issues and sustainable development requires the integration of inquiry-based learning, critical thinking development, interdisciplinary connections, and digital technologies. However, the issue of improving teaching methodology for these topics in Grades 5–6 within elective science courses remains insufficiently explored, which determines the relevance of the present study.

Within this context, we designed and implemented an elective course called *"Science Around Us"* for middle school students (Grades 5 and 6) at Gymnasium No. 4 named after A.S. Pushkin in Kazakhstan. The course was conceived to bridge content from geography, biology, chemistry, and physics under the unifying themes of global challenges and sustainable development. By exploring scientific concepts in the context of real-world issues – such as climate change, energy sustainability, environmental pollution, and human health – the course aimed to increase students' awareness of sustainable development while also strengthening their general scientific literacy. A key feature of *"Science Around Us"* is its emphasis on research-based learning and critical thinking. Rather than learning science facts in isolation, students engage in inquiry-driven projects, experiments, and problem-solving activities that relate directly to global and local challenges. This pedagogical approach is intended to stimulate curiosity and deeper understanding; indeed, inquiry-based learning methods have been shown to improve students' academic achievement in science compared to traditional lecture-based instruction [4]. Multiple studies and meta-analyses have found a clear positive effect of inquiry-oriented and student-centered science teaching on student learning outcomes [4]. By involving students in formulating questions, investigating problems, and reflecting on findings, the course strives to develop not only content knowledge but also scientific thinking skills and the ability to evaluate information critically – competencies identified as essential for addressing sustainability issues [2]. Furthermore, situating science learning in real-life problems (for example, studying air quality by measuring local pollution levels, or learning physics principles through renewable energy projects) provides context and relevance that can motivate learners and improve retention [3]. Such context-driven, applicable learning experiences are expected to nurture students' sense of responsibility and agency regarding societal and environmental challenges [2].

The current study investigates the impact of the *"Science Around Us"* elective on students' understanding of global challenges and sustainable development after one academic term. We posed the following research question: *Does participation in an interdisciplinary, sustainability-focused science course significantly enhance middle school students' knowledge of and engagement with global challenges and sustainable development concepts?* We hypothesized that students enrolled in this course would show measurable gains in conceptual understanding of sustainable development issues and improved ability to connect scientific ideas across disciplines. To evaluate this, we conducted pre- and post-course knowledge assessments and analyzed the results. Additionally, we qualitatively observed student engagement and critical thinking during course activities. The object of the research is the educational process involved in teaching global challenges and sustainable development to middle school students. The subject of the research is the effect of an interdisciplinary science course (*"Science Around Us"*) on students' knowledge and skills related to sustainable development. The purpose of the article is to present the design of this elective course and assess its educational outcomes, thereby providing evidence and insights into how integrating global challenge themes in secondary education can improve student learning. To achieve this purpose, the study addressed the following tasks: (1) develop an interdisciplinary curriculum combining geography, biology, chemistry, and physics content around sustainability themes; (2) implement the course with Grade 5–6 students in a gymnasium (advanced secondary school) setting; (3) conduct initial (baseline) and intermediate assessments of students' knowledge on key topics; (4) analyze the changes in student performance and understanding; and (5) discuss the implications of the findings for curriculum design and pedagogy in the context of ESD. The structure of the article reflects these tasks: after this introduction, we describe the methods and materials of the study, then present and discuss the results, and finally offer conclusions regarding the course's effectiveness, its novelty, and its practical significance.

Materials and methods. *Course Setting and Participants:* The study was carried out at Gymnasium No. 4 named after A.S.Pushkin in Almaty, Kazakhstan. This gymnasium is a secondary school known for its academic focus. The elective course *"Science Around Us"* was offered to five classes in total: three Grade 5 classes (5A, 5B, 5C) and two Grade 6 classes (6A, 6B). In the Kazakhstani education system, Grade 5 and 6 students are generally 10–12 years old. All students in these classes (approximately 25–27 students per class, for a total of N ≈ 130 participants) took part in the elective, which was integrated into the school's curriculum as an optional science enrichment course. Attendance was high and consistent throughout the term, indicating strong interest either from students or encouragement by teachers and parents. Prior to the introduction of *"Science Around Us,"* students had been studying standard science subjects (biology, geography, etc.) as separate disciplines; however, they had not received formal instruction explicitly focused on global challenges or the UN Sustainable Development Goals.

Course Design and Content: "Science Around Us" was designed as an interdisciplinary curriculum unit spanning one academic term (quarter). The course met once per week for a 45-minute session over the term (approximately 8–10 weeks in the first term of the school year). Each session centered on a specific theme related to global challenges and sustainable development, integrating content and skills from multiple scientific domains. Table 1 outlines example topics covered in the course and their interdisciplinary connections. For instance, one lesson on **"**Climate Change and Energy" combined geography (climate zones, weather vs. climate), physics (the greenhouse effect, energy sources), chemistry (CO_2 and combustion), and social studies (renewable energy solutions). Another lesson on "Human Health and the Environment" linked biology (disease and nutrition), chemistry (water and air quality), and geography (distribution of health issues globally). A guiding principle in each lesson was to relate scientific concepts to real-world issues that students could understand and investigate. Lessons typically began with a driving question or problem scenario (e.g., "Why are scientists concerned about rising CO_2 levels?" or "How does plastic waste affect living organisms?"). Students engaged in various active learning strategies such as small-group discussions, hands-on experiments or demonstrations, analysis of simple datasets, and short research projects. They were encouraged to formulate hypotheses, gather evidence (for example, by measuring something or researching information), and draw conclusions, thereby practicing the scientific method in a real-world context. The course also incorporated elements of project-based learning: in the second half of the term, student teams chose a sustainability challenge (like water conservation at home or reducing waste in school) and worked on a mini-project to propose solutions, which they presented to the class. By structuring the course around authentic problems and multi-disciplinary inquiry, we aimed to make the learning experience more engaging and meaningful, reinforcing the idea that science is interconnected and *"around us"* in everyday life. Notably, this approach mirrors what education experts recommend for fostering critical thinking – embedding it across disciplines through inquiry and problem-solving, rather than treating it as an isolated skill [2]. Throughout the course, teachers acted as facilitators, guiding inquiry with thoughtful questions and encouraging reflection, while students took an active role in constructing knowledge.

Assessment Methods: To evaluate the impact of the course on students' understanding, we employed a pre-test/post-test evaluation design. At the very start of the term (during the first session of *"Science Around Us"*), students were given an initial knowledge assessment. This baseline test consisted of 20 multiple-choice and short-answer questions covering fundamental concepts related to the course themes (e.g., basic definitions of sustainable development, identification of major global challenges like climate change or poverty, elementary science facts pertinent to those challenges, and simple scenario-based questions requiring application of science concepts). The questions were developed by the course instructors and vetted by subject teachers to ensure they were age-appropriate and aligned with curriculum standards. Though not an exhaustive test of all possible knowledge, this assessment provided a snapshot of students' starting familiarity with global challenge topics and their ability to make connections across science subjects. Students completed the test individually in class, and it was scored

out of 100% (each question carrying equal weight, with partial credit for short-answer items as appropriate). The average score on this initial test represented the baseline knowledge level for each class.

After approximately two months, at the end of the first academic term (following completion of the course's planned lessons for that term), we administered an intermediate assessment to the same students. This test was designed to be parallel in format and difficulty to the pre-test, covering the same broad topics and skills. Many questions were analogous (for example, a pre-test question "List two causes of climate change" might correspond to a post-test question "List two effects of climate change"), allowing us to gauge gains in specific knowledge areas. The post-test also included a few questions requiring students to explain concepts in their own words or analyze a new scenario using concepts learned in the course, in order to assess deeper understanding and transfer of knowledge. The post-test was likewise scored out of 100%. Both the pre- and post-assessments were not counted toward students' grades in any subject; they were presented as a diagnostic tool to help instructors understand learning outcomes, and students were encouraged to do their best without fear of penalty. We obtained informed assent from the students and permission from school administration to use these test results for research, ensuring confidentiality.

In addition to the quantitative knowledge assessments, qualitative observations were made throughout the course by the instructors (who were also the researchers in this study). After each session, instructors took brief notes on student engagement, participation in discussions, and any notable instances of critical thinking or creativity (for example, a student making an insightful cross-disciplinary connection, or groups coming up with innovative ideas during project work). While these observations were informal, they provided contextual understanding to complement the test score data. We also gathered informal feedback from students at the end of the term through a short reflective questionnaire where students could write what they enjoyed or learned from the course. This feedback was not systematically analyzed for this article, but representative comments are noted in the discussion to illustrate student perceptions.

Data Analysis: The primary analysis focused on the comparison of pre-test and post-test scores to determine if there was a statistically significant improvement in students' knowledge after one term of *"Science Around Us."* For each class (5A, 5B, 5C, 6A, 6B), we calculated the mean and standard deviation of the test scores before and after the course. We performed a paired sample *t*-test for each class and for the aggregate sample (combining all five classes) to assess whether the increase in scores was significant. Given the relatively large number of students ($n > 20$ per class), the *t*-test is a reasonable approach for gauging significance of mean differences. We set a significance level of $\alpha = 0.05$ for these tests. We also computed the effect size (Cohen's *d*) for the score improvements to understand the magnitude of the educational effect. Additionally, we examined score distributions and the percentage of students achieving a satisfactory performance (for instance, scoring ≥70%) before vs. after the course. The qualitative observations were reviewed to identify common themes or examples regarding student engagement and skill development, which are integrated in the Results and Discussion to enrich the interpretation of the quantitative findings.

Results and Discussion. *Knowledge Gain after One Term:* Analysis of the assessment scores revealed a clear and significant improvement in students' understanding of global challenges and sustainable development concepts after participation in the *"Science Around Us"* course. Figure 1 illustrates the average test scores before and after the course for the combined group of students, while Table 2 provides detailed results by class. Prior to the course, the overall mean score on the baseline test was 46.7% (SD ≈ 12%). This relatively modest average reflects that most students had only fragmentary prior knowledge of the interdisciplinary topics – for example, many could identify obvious global issues like pollution or climate change, but few were familiar with the term "sustainable development" or could explain the interconnections between scientific and social aspects of these challenges. After one term of instruction, the overall mean post-test score rose to 81.3% (SD ≈ 10%). This constitutes an average gain of approximately +34.6 percentage points. A paired *t*-test confirmed that the improvement

in scores from pre- to post-test was highly statistically significant ($t(129) \approx 25.4$, $p < 0.001$) for the aggregated sample of five classes. The effect size was very large (Cohen's $d \approx 2.5$), suggesting that the course had a substantial educational impact.

All five individual classes exhibited significant gains. For instance, Class 5A's mean score increased from 43% to 78%, Class 5B from 45% to 80%, and Class 5C from Forty-two percent of questions answered correctly at baseline to 76% at intermediate. Similarly, the Grade 6 classes improved from about 52–55% averages initially to about 85–88% on the post-test. In general, the 6th graders scored slightly higher than 5th graders on both pre- and post-tests, which is not unexpected given their extra year of general schooling. However, the magnitude of improvement was similar across grades (gain of ~34–35 points on average), indicating that the course was effective for different age levels in our sample. The percentage of students achieving a score of 70% or above (a threshold we might consider as demonstrating solid understanding) jumped dramatically from roughly 15% of students at pre-test to about 90% at post-test. In other words, by the end of the term, the vast majority of participating students could correctly answer most questions about sustainable development topics that they previously did not understand. This includes being able to articulate definitions (e.g., explaining what "sustainable development" means), classify challenges (distinguishing environmental vs. social dimensions of global issues), and apply scientific concepts to new situations (for instance, interpreting a simple data chart on rising global temperatures and linking it to the greenhouse effect concept learned in class). Figure 2 presents a sample question and the distribution of answers before and after the course, illustrating the shift from prevalent misconceptions to largely correct explanations after instruction.

These results provide empirical evidence that an interdisciplinary, challenge-focused science course can significantly enhance middle school students' content knowledge regarding sustainability and global challenges. The magnitude of improvement is notable; an average post-test score above 80% suggests that students not only memorized facts but grasped key concepts well enough to succeed on varied question formats. The novelty of this finding in the context of Kazakhstan's secondary education is worth emphasizing. To our knowledge, *"Science Around Us"* represents one of the first concerted efforts in a Kazakhstani secondary school to integrate multiple sciences around sustainable development themes and to formally measure learning outcomes from such integration. The positive results align with global trends reported in the literature, reinforcing that when students see the *connections* between scientific knowledge and real-world problems, their understanding deepens. This is in line with Hendricks (2023), who observed that interlinked learning experiences *"allow students to transfer skills and knowledge acquired in one area to another,"* helping them see cross-cutting patterns and thereby *fostering a holistic understanding [3]*. In our case, students often commented that they enjoyed seeing how topics in one class related to another – for example, how the concept of "energy" was discussed in physics (in terms of renewable energy technology) and also in geography (in terms of energy resources distribution) and environmental science (in terms of energy's impact on climate). This integrative approach likely aided retention: concepts were reinforced in multiple contexts, making learning more robust.

Moreover, the improvement we observed is consistent with the idea that inquiry-based and student-centered pedagogies enhance learning outcomes in science. Our course deliberately moved away from rote learning; instead of simply telling students about the SDGs or the water cycle, we engaged them in discovering and researching these ideas. The large knowledge gains suggest that even young students can successfully learn through inquiry when given appropriate guidance – a finding echoed by prior research showing that guided inquiry can yield strong achievement gains in science education [4]. By asking questions, conducting small experiments, and discussing as a group, students likely constructed a more meaningful understanding of the material than they would have through passive listening. This resonates with Minner et al. (2010), who found a *"clear, positive trend favoring inquiry-based instructional practices"* in science education, meaning students tend to learn more effectively when actively involved [5]. Our study adds to that evidence, illustrating it in the context of sustainability topics and a cross-curricular format. It also supports the approach advocated by critical-thinking

education experts: integrating inquiry and problem-solving across different subjects creates a richer learning environment that can sharpen students' reasoning skills [6].

Development of Critical Thinking and Engagement: Although our primary measured outcome was content knowledge (as reflected in test scores), qualitative observations during the course suggest that students also developed transferrable skills and attitudes, notably in critical thinking, collaboration, and personal engagement with global issues. For example, during a lesson on climate change, students were presented with a graph of global temperature rise and CO_2 concentration over time. Initially, many seemed unsure how to interpret the data. However, as the teacher guided them with questions ("What pattern do you notice? How could CO_2 be related to temperature?"), students began to hypothesize relationships. One group even drew on their math skills to describe the trend ("it's increasing faster after the year 1950, kind of exponential"). By the end of that activity, students not only learned the intended science content (the link between greenhouse gases and warming) but also practiced analyzing data and drawing evidence-based conclusions – a critical thinking exercise. In another session focusing on local environmental issues, students conducted a simple audit of classroom trash to categorize what could be recycled or reduced. This hands-on activity spurred a lively discussion about consumer habits and waste, with students debating solutions like "should we ban plastic bottles in school?" They were critically evaluating possible actions, weighing pros and cons – precisely the kind of higher-order thinking that sustainability education aims to promote [7]. These anecdotes illustrate how the course provided a platform for students to exercise judgement and reasoning about real-life problems. By encountering complex issues that do not have single easy answers, students were challenged to think more broadly and consider multiple factors, which can strengthen their critical thinking dispositions [8]. Indeed, sustainability topics are well-suited for this because they inherently connect science with economics, ethics, and societal choices. As noted in a recent European School Education Platform report, *"sustainability education is an ideal way for pupils to develop critical thinking while growing their sense of responsibility for real-life challenges" [8]*. Our classroom experience supports this: many students expressed a sense of empowerment, saying they felt they *could* do something about problems like littering or energy saving after learning about them. This shift from passive awareness to active interest is a qualitative outcome that, while hard to quantify, is immensely valuable in education for sustainable development.

Implications for Curriculum and Pedagogy: The success of *"Science Around Us"* carries several implications. Firstly, it demonstrates the feasibility and benefits of interdisciplinary electives at the middle school level. Often, school timetables are rigidly divided by subject, which can create silos of knowledge. Our model shows that with administrative support, a cross-department collaboration (in our case, teachers from geography, biology, chemistry, and physics departments co-developed the course) can result in a cohesive learning experience that breaks down these silos. The improvement in student outcomes provides an evidence-based rationale for curricular innovation: integrating subject matter around themes of global significance can reinforce learning in each individual subject as well. For instance, students reported that what they learned about water chemistry in the elective later helped them understand a concept in their regular chemistry class, and vice versa for geography. This synergy suggests that interdisciplinary courses need not compete with traditional subjects; instead, they can enrich the overall curriculum and help students build connections that enhance mastery across the board. Educational research supports this view, noting that interdisciplinary approaches help students form a holistic understanding and see the relevance of their classroom learning to the outside world [9]. Schools aiming to prepare students for the complexities of the 21st century should therefore consider adding modules or projects that cut across subject boundaries, especially centered on real-world issues that resonate with students' lives.

Secondly, our findings underscore the importance of active, student-centered learning strategies in improving educational outcomes. The dramatic jump in knowledge scores and the enthusiastic participation we observed both attest that students learn more – and enjoy learning more – when they are actively involved. Methods such as problem-based learning, scientific inquiry, discussions, and collaborative projects were integral to this course's design and clearly contributed to its effectiveness.

Teachers adopting this approach act less as lecturers and more as facilitators or coaches. This can initially be challenging in systems accustomed to teacher-centered instruction, but the payoff in student engagement and understanding is significant. As one 11-year-old student wrote in her feedback, *"I liked that we did things by ourselves – like a small research – it made me remember better and I felt like a scientist."* Building such confidence and interest in science is an added benefit of the pedagogical approach used. It aligns with broader educational recommendations that call for moving beyond rote memorization to develop higher-order skills like analysis, evaluation, and creativity in learners [10]. Our course combined content knowledge with these skills by necessity – to solve a given sustainability problem, students had to apply scientific facts, analyze information, and consider solutions, thereby practicing critical thinking in context. This *embedded* approach to teaching skills is seen as more effective than trying to teach skills in abstraction [11]. We recommend that educators looking to promote critical thinking in their classrooms use interdisciplinary real-world problems as a context, as we have done, since this naturally invites questioning and multiple perspectives.

Thirdly, the positive outcome of *"Science Around Us"* supports the agenda of scaling up Education for Sustainable Development in formal education. Given that Kazakhstan's national curriculum is moving toward including ESD principles [9], our pilot can serve as a practical example of what ESD might look like at the school level. It provides a case study of how global and local challenges can be introduced to young students in a way that is academically rigorous yet accessible. One key insight is that students are capable of engaging with "big" issues if those issues are presented at the right level and tied to concrete activities. For example, while "climate change" is a vast topic, our specific experiment of building a simple greenhouse model or analyzing temperature data made it tangible for students. Similarly, discussing a local environmental concern (like air pollution in Almaty on a particularly smoggy day) helped students relate global challenges to their own community. Such localization of global issues is known to enhance student interest and comprehension, and is a recommended practice in ESD methodologies [1]. By sharing our curriculum design and results, we hope to inform educators and curriculum developers in Kazakhstan and beyond about effective strategies to bring sustainable development into the classroom. The improvement in knowledge and critical thinking we observed shows that even within a single term, meaningful progress can be made. Over longer periods or multiple grade levels, one could expect even greater impact – potentially influencing students' values and behaviors, which are ultimate goals of ESD not measured in this study.

Limitations and Further Research: While the results are encouraging, we should acknowledge the limitations of this study. Firstly, the assessment focused primarily on cognitive knowledge gains. Other outcomes, such as changes in student attitudes towards the environment or development of specific skills (e.g. teamwork, scientific inquiry skills), were not formally measured. It is possible that some students improved their test scores but might not retain the information long-term or translate it into action. Longitudinal studies would be useful to see if knowledge and interest in sustainability persist beyond the immediate course. Secondly, there was no control group in our design – all five classes received the intervention. We therefore cannot conclusively attribute all gains solely to the course, as students might have also learned from other sources during the term. However, given that global challenges content was not part of their regular curriculum and the large magnitude of improvement, it is reasonable to infer the course played a central role. Future research could include a comparison group or employ a crossover design to strengthen causal claims. Thirdly, our evaluation did not include a detailed item analysis to identify which concepts students struggled with most or which aspects improved the most. Such analysis could inform fine-tuning of the curriculum (for example, if we found that understanding of economic dimensions of sustainable development lagged behind environmental knowledge, we could adjust the course to address that). Lastly, the study was conducted in one school which, as a gymnasium, may have students particularly motivated or able to take on extra courses. The success of *"Science Around Us"* in a different school context (e.g., a general education school or in rural areas) would need verification. Nonetheless, the fundamental strategies used – interdisciplinary integration and inquiry learning – are pedagogically universal and supported by broader research. We

anticipate similar positive outcomes could be achieved elsewhere with proper adaptation and teacher training.

In summary, the discussion of our results suggests that integrating sustainable development and global challenge education into middle school science through an elective like *"Science Around Us"* is both feasible and beneficial. The course significantly raised students' knowledge and engaged them in higher-order thinking about real-world problems. This mirrors global educational objectives: to prepare students not just in academic content, but to be informed, critical, and responsible citizens who can contribute to solving the pressing challenges of our time [1].

Conclusion. The elective course *"Science Around Us"* demonstrated a successful model for enhancing students' understanding of global challenges and sustainable development at the middle school level. Through its interdisciplinary content spanning geography, biology, chemistry, and physics, and its emphasis on research-based, student-centered learning, the course achieved a marked improvement in participating students' knowledge within a single academic term. Students showed significant gains in their grasp of key concepts (as evidenced by test score increases) and exhibited an ability to connect ideas across subjects when reasoning about real-world issues. These outcomes provide evidence that even young learners (Grades 5–6) can engage deeply with complex topics like sustainability when taught in an interactive and integrated manner. The findings contribute to the growing body of literature affirming the value of Education for Sustainable Development approaches in primary and secondary education. In line with UNESCO's vision for education's role in the 21st century [1], our study confirms that integrating global challenges into the curriculum can foster the *"values and skills that lead to sustainable and inclusive growth" [1]*. Importantly, this work is novel in the context of Kazakhstani education: it represents an early practical implementation of ESD principles in a secondary school setting with measurable positive results.

From a practical perspective, the success of *"Science Around Us"* suggests that schools and educators should be encouraged to experiment with interdisciplinary courses or projects focusing on real-world problems. The course's format can serve as a template for similar initiatives. For instance, other schools might implement a sustainability club, a project week on global issues, or integrate SDG-related modules into existing science classes. The critical factors seem to be providing relevance (connecting science to everyday life and global trends), encouraging inquiry and critical thinking (letting students ask questions and seek answers), and bridging disciplinary boundaries (showing that biology, chemistry, physics, and geography knowledge all intersect in understanding issues like climate change or public health). The improvement in our students' performance and enthusiasm indicates that such approaches not only impart knowledge but also potentially inspire a greater interest in STEM and civic responsibility. In the long term, educating students in this way could contribute to a more sustainability-conscious mindset, as students carry these lessons into higher grades and eventually into society.

In conclusion, enhancing students' understanding of global challenges and sustainable development is both an educational imperative and an achievable goal. The elective course described in this article serves as a proof-of-concept that with thoughtful curriculum design and active pedagogies, young learners can significantly broaden their awareness of world issues and develop skills to think critically about solutions. This aligns with national and international calls to transform education to meet the demands of our rapidly changing world [1]. We recommend that educational stakeholders – from school administrators to curriculum developers and policy makers – support and scale up such interdisciplinary and problem-focused learning opportunities. By doing so, we invest in building a generation of learners who not only excel in academic competencies but are also prepared to engage with and address the sustainability challenges that lie ahead. The experience at Gymnasium No. 4 provides a hopeful example: when students are given the chance to explore *the science around us* in the context of global challenges, they rise to the occasion, learning with enthusiasm and purpose. This bodes well for the future, as these empowered learners will be better equipped to contribute to a sustainable and equitable world.

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