

Article

Assessing High School Students' Knowledge of Sustainability

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Abstract

The purpose of our study is to build a valuable regional case by addressing sustainability challenges within the regional context of Bosnia and Herzegovina (BiH). Based on this intent, we examined regional sustainability practices and performed a quantitative analysis. We assessed the sustainability knowledge of high school students in BiH using the revised Assessment of Sustainability Knowledge (ASK) test. The study analysed student performance ($N = 297$) across the environmental, social, and economic domains of sustainability. Results revealed a mixed understanding of basic sustainability principles. Using a one-way ANOVA, we found no significant differences in test scores across years of study. Performance stratification showed that nearly two-thirds of students scored less than half of all points, highlighting substantial knowledge deficits. A comparison of sustainability knowledge representations reveals that students are most knowledgeable about the social domain, followed by the environmental domain, whereas their comprehension of the economic domain is much less developed. Our findings advocate for a more balanced approach to sustainability education that addresses not only the environmental and social but also the economic aspect of sustainability holistically. These findings are crucial for informing and tailoring sustainability education curricula in BiH to specifically target identified knowledge gaps and prevalent misconceptions.

Keywords: sustainability knowledge; ASK test; high school students; education for sustainable development; Bosnia and Herzegovina

1. Introduction

People barely recognise that the air they breathe and the other natural resources they use are just as rare, vulnerable, and endangered as gorillas and other critically endangered species that may become extinct. Evidently it is easier to count gorillas and determine they are at the edge of extinction than to grasp how much quality air and other natural resources are still available to us, what the different environmental impacts of various technologies are, and the time it takes for nature to recover. The once-fallen tree would not grow magnificent in a single day, let alone a year.

It is unsettling how pollution and unsustainable environmental practices harm people's health and quality of life all over the world [1–6]. The World Health Organization (WHO)'s [7] health and environment scorecards show the countries' exposures and impacts on people's health and recognise that many diseases and premature deaths are directly linked to air pollution, unsafe drinking water, and inadequate sanitation. Undoubtedly, the environmental, social, and economic domains of sustainability are tightly intertwined. Environmental challenges not only strain the quality of life but also shrink the

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national and global economy [8,9]. In the middle of this, it is incomprehensible that decision-makers globally continue to underweight environmental and pollution risks and insufficiently integrate considerations of environmental degradation into decision-making processes, particularly in infrastructure-related projects in ecologically sensitive areas or regions of high ecological value. Among many such decisions, let us mention the construction of the Avenida Liberdade highway [10–12] in preparation for the 2025 United Nations (UN) Climate Change Conference (COP30), which is being built through previously forested areas and has raised concerns about long-term damage and environmental impact in the Amazon rainforest region [13].

Without systematically providing and improving quality sustainability education [14,15] and raising awareness about these issues, it is difficult for people to recognise the threats they face, let alone apply sustainable practices. Aside from sustainability literacy [16–18], attitudes and behaviours, frameworks such as sustainable development goals (SDG) [19,20], and sustainability competence models [21–23] form the basis for sustainability research. Building on that, UNESCO [24] suggests learning and teaching approaches that raise awareness of the SDGs and connect them to key cross-cutting competencies, cognitive, socio-emotional, and behavioural learning objectives. The Assessment of Sustainability Knowledge's (ASK) test was selected as the most suitable instrument due to its emphasis on knowledge evaluation rather than normative or behavioural aspects. Additionally, we opted to employ the ASK test to facilitate the comparison of the assessment of environmental, economic, and social domains of sustainability knowledge. Due to specific vulnerabilities, Bosnia and Herzegovina (BiH) represents a particularly relevant case for our research [25], which examines how global and regional sustainability challenges, along with previously undertaken measures to enhance knowledge and awareness about environmental, societal, and economic risks, concretely illustrate the current level of students' understanding of these three sustainability domains in BiH. We hypothesised that:

H1. *Students' year of high school is associated with performance on the Assessment of Sustainability Knowledge (ASK) test.*

H2. *Knowledge in the economic domain of sustainability is lower than knowledge in the environmental and social domains.*

The purpose of our study is to address sustainability challenges within a regional context of BiH and to build a valuable regional case by providing a rich overview of existing sustainability practices and the environmental situation in BiH. In this context, we conducted a rigorous literature review that focused on examining regional sustainability challenges and performed a quantitative analysis to test the differences in sustainability knowledge among high school students. To the best of our knowledge, the research using the ASK measurement instrument has so far not been applied in the context of BiH. The previous studies from BiH mostly rely on metrics such as awareness, attitudes, or values (e.g., [26–29]). Therefore, this study is, to our knowledge, the first to apply the ASK measurement instrument in BiH. Within the quantitative analysis based on the ASK measurement instrument, we (H1) examine whether year of high school is associated with sustainability knowledge measured by the revised Assessment of Sustainability Knowledge (ASK) test tailored to the local context and (H2) assess the representation of the social, environmental, and economic domains of sustainability between the study participants. This research is especially relevant since Zwickle and Jones [30] previously identified a lack of research on the economic and social domains of sustainability knowledge compared to the environmental domain. Based on our findings from the literature review and quantitative analysis, we aim to provide policymakers, principals, and educators with

insightful information on sustainability practices and instructional approaches that they can and should adapt in the future to tailor sustainability education curricula in BiH.

2. Literature Review

The WHO [31], World Bank [8,9], and European Environment Agency (EEA) [32] emphasise that floods, wildfires, air pollution, water quality, and other environmental risks in BiH substantially compromise people's health and their quality of life as well as shrink the national economy. Externalities such as the inability to open the windows and grounded planes seriously affect the quality of life [33] and the economy. WHO's [31] score of exposure, health impact, and policy, however, seems more lenient toward the situation in BiH than, for example, the Air Quality Index (AQI) [34], which has several times placed Sarajevo among the first three on the list of the world's most polluted cities [33,35]. Streimikiene's [36] research, which compares green growth indicators such as total national emissions, energy consumption per economic output, share of renewable energy, air pollutants, waste management and recycling, organic farming, and protected areas, found that BiH (BiH) performed the worst among the five Western Balkan countries studied.

It is impossible to expect that the air quality that sows deaths, the number of wildfires destroying our environment's lungs, the floods that leave nothing but devastation, and the overall environmental situation will improve without appropriate measures. This means that improvements cannot occur without reducing the number of highly polluting vehicles, decreasing coal use, enhancing building energy efficiency [35,37,38], and implementing sustainable practices [39], such as better urban planning and waste management, among others. The key issue is not only how to implement the previously mentioned sustainable practices but, most of all, how to prevent unsustainable practices such as reckless exploitation of resources that contribute to the vicious cycle of rising temperatures, smog in cities, and unsafe drinking water that directly affect residents. For example, while it may seem like building additional air conditioning systems is a solution to the increasing fatalities caused by high temperatures, their use actually worsens air quality and causes temperatures to rise even further [40,41]. Such practices only fuel that vicious cycle, so the search for different environmentally friendly technologies that would be better able to suspend this vicious cycle is ongoing (e.g., cooling technologies [42]). Technologies with lower environmental footprints and those that support circular economies need to be implemented and further improved [43]. The situation becomes more complex when technologies are labelled as sustainable but are actually unsustainable [44] in the long term, with some merely promising environmental friendliness that they cannot fulfil. While many environmentally hazardous technologies moved to economically weaker countries [45,46], some new technologies marked as sustainable are neither environmentally friendly nor sustainable in the long run (e.g., electric vehicles [44]). Therefore, we need support for green technology innovation and the development of new technologies that will truly preserve the environment in the long run. We need to further improve policies and legislation [47,48] to create opportunities for entrepreneurial development and for people to work in businesses that promote sustainable development and demonstrate environmental care in practice.

Future generations should inherit a better environment and implement well-thought-out steps to preserve it for future generations. Sustainable initiatives, however, frequently necessitate investment and innovation. Therefore, sustainability requires solid economic performance, public finance stability, institutional trust and integrity, and anti-corruption measures [49,50]. In BiH, post-war reconstruction and transition [47,51] took place along with the sustainability initiatives. Petković et al. [52] found that sustainability has a significant impact on an organisation's corporate social responsibility [53–55]. Different

sectors of the BiH economy have received financial support in the form of grants or loans [51] to implement measures and improve procedures aimed at reducing the environmental burden. Nevertheless, the efforts to promote green transition and employment in green jobs have had mixed and unbalanced results across different sectors [56].

According to a study by Silajdžić et al. [57] on green entrepreneurship in transition economies like BiH, there is a lack of institutional and governmental support for green tech entrepreneurship initiatives. Additionally, they observe that educational institutions do not recognise their important role in fostering the development of green entrepreneurship [57]. This scenario is also highlighted by Shala and Berisha [58], which places BiH among the countries struggling the most to establish responsible fintech practices and foster sustainable practices, resulting in one of the lowest rankings for achieving environmental, social, and governance goals.

Our research focuses on the interconnected environmental, social, and economic sustainability domains. The education sector [59] is critical in addressing all three domains because it enables connecting, promotes entrepreneurial green tech initiatives, enhances values, and encourages people to get involved and support practices with a lower environmental footprint. The education sector, in this regard, plays a critical role, since it, along with the media, local community, family, and friends, contributes to the broader environmental knowledge in different scientific disciplines and awareness about what our planet is facing [60].

Without raising knowledge and awareness about the situation and the need for necessary measures, such as reducing coal energy and power plants [61], preventing illegal landfills and unsafe waste disposal that can harm drinking water, and ensuring smart urban planning, it will be difficult to establish a consensus among individuals, companies, and communities to refrain from unsustainable practices. Furthermore, Dogmus and Nielsen [62] emphasise the importance of being diligent about specific sustainable actions and their concrete impacts on local residents, empowering them to determine what is and is not sustainable from their perspective. Prevolšek et al. [63], for example, who investigated the sustainability of tourism in selected local communities based on economic, social, and environmental domains, found no examples of sustainable tourist offerings in those communities. Further, Cvetković et al. [60] observe notable differences in environmental knowledge and awareness among students from Montenegro and North Macedonia and provide in-depth analysis of strategies, solutions, and practices that these two countries have adopted or shall adopt to address the challenges.

Raising awareness in the wider population and including sustainability in education curricula from early childhood onwards [64–66] is essential for fostering responsible decision-making. In turn, informed decision-making can contribute to future policymakers and decision-makers refraining [60] from damaging and sometimes illegal practices, such as the disposal of hazardous waste [67], which only provides short-term economic benefits to individuals or companies.

As researchers (e.g., [60]) have stated previously, understanding young people's knowledge and perceptions of environmental issues is critical for "developing effective educational strategies and policies that promote sustainable practices" [60], as those who are more knowledgeable are generally more likely to adopt sustainable and environmentally friendly behaviours [68,69]. In contrast, Nikolić et al. [70], who supported a significant relationship between circular economy attitudes and beliefs and sustainability, did not identify a significant relationship between awareness and behaviour in their sample. Nevertheless, mainstream research generally supports the relationship between knowledge, awareness, and behaviour.

3. Methodology

The methodology section contains the justification for the measurement instrument used, including its adaptation to the local context, a description of the participants and data collection, and a description of the data analysis procedure.

3.1. Measurement Instrument

To assess sustainability knowledge among high school students, we applied the revised ASK test [71–75], which, to our knowledge, was the first time it was used in the BiH context. In comparison, Fošner [76] previously conducted the ASK test with Slovenian higher education students, while Leiva-Brondo [72] conducted it with Spanish higher education students.

To highlight the differences in approaches and measurement instruments, it is important to note that these instruments vary based on whether they assess literacy related to knowledge, sustainability competencies, perceptions [77], attitudes, or behaviour [78], or whether they rely on entirely objective measurements. Other measurement instruments concentrate on either sustainable development goals (SDGs) [79] or competencies derived from sustainability competence models [21,22]. Some studies provide comparisons of results from different locations [80]. Further, UNECE [81] focuses on the development of teachers' competencies, which include holistic, integrative thinking, envisioning change, and achieving transformation by shaping people's perspectives, changing pedagogical approaches, and changing education systems.

There are various measurement instruments available to assess sustainability literacy [16–18,82]. The TASK test [18], a more knowledge-focused component of the Sulitest framework [82,83], is still used in contexts related to the SDGs and policies. In contrast, the ASK test, the measurement instrument used in our study, assesses factual and conceptual sustainability knowledge as distinct cognitive constructs. The ASK test was chosen as the most appropriate instrument because it focuses on knowledge assessment rather than normative or behavioural dimensions. Furthermore, we decided to use the ASK test since we intended to compare the measurement of the environmental, economic, and social domains of sustainability knowledge. Our survey, therefore, does not measure attitudes or behaviour, which reside on separate measurement instruments (e.g., [30,73–75]). However, although it does not measure behaviour, the sustainability knowledge measured by ASK has previously been shown to be correlated with behaviour in models uncontrolled by attitudes, norms, and perceived controls [73].

The ASK test therefore evaluates students' knowledge of basic sustainability principles, including Brundtland's definition of sustainable development [84,85], which Zwickle and Jones [30] recognised as the most prevalent definition, presupposing that the abilities of future generations are not compromised by meeting the needs of current generations. Although long-term orientation versus short-term welfare is at the core of different concepts of sustainability, the concept of sustainability evolved [86,87]. Different authors emphasise different aspects of a sustainable future [88], such as ethical dimensions and corporate responsibility [89,90]. Kuhlman and Farrington [91], for example, argue that sustainability is a policy construct and that social and economic aspects of it are not separate domains. While we find it important to point out these differences, we have decided to base our research on the knowledge-based ASK measurement instrument that foresees three different domains.

The answer keys follow widely used educational terms of sustainability domains, consistent with secondary-school curricula. The ASK measurement instrument was initially developed by Zwickle et al. [71] and later revised by Zwickle and Jones [30]. Our survey relies on the revised version [30] of the ASK measurement instrument, whereby we only omitted one item related to the reasons for lower electricity prices in the US. Apart

from that, minor wording modifications, which did not alter the conceptual meaning, measurement objective, or content validity, were made to the selected items to ensure contextual relevance. The measurement instrument we applied was translated from English to the local language and was previously applied among the Slovenian higher education students [76].

3.2. Participants and Data Collection

The online survey consisted of a mix of multiple-choice questions that addressed the environmental, economic, and social aspects of the topic without providing domain-specific titles. The questionnaire was distributed to 12 high schools from BiH between May and June 2025. Although efforts were made to ensure regional representation of participating schools, some invited schools did not participate. Among the high schools that agreed to participate, the schools' principals approved the participation, and the teachers of participating schools distributed the questionnaire to the students. All participants provided informed consent to participate and were informed that the survey was fully anonymous. This study did not require ethics committee approval because the survey collected no personal data or sensitive information from participants. Instead, it was designed to gather general knowledge without any identifiers that could link responses to specific participants. As a result, the respondents faced no risk, and all data were processed and analysed in aggregate form to ensure confidentiality and privacy.

In the end, only students from five high schools participated in the study, with the Sarajevo Canton region of BiH having the highest representation in our sample. In total, we collected a total of 297 fully completed questionnaires (Table 1) using the 1KA online survey tool. Most participants in the study attended economic high schools, while some attended technical and other vocational high schools.

By gender, participants were mostly female (63%). By grade, fourth-year students formed the largest group (41%), followed by third-year students (28%). First- and second-year students were less represented (17% and 14%). The skew toward third- and fourth-year students from the economic high schools should be considered in further analyses and interpretations. When conducting any analyses or interpretations, it should be considered that our sample is unrepresentative, and the generalisation to the broader high school population is therefore limited.

Table 1. Demographic characteristics of the student sample (N = 297).

Demographic Characteristics	Options	Frequency	Relative Frequency (%)
Gender	Male	109	37%
	Female	188	63%
Year of high school	First year	52	17%
	Second year	41	14%
	Third year	82	28%
	Fourth year	122	41%

3.3. Data Analysis Procedure

In the following section, we analysed the ASK test results. To test H1, whether there are differences in ASK test scores of students based on the year of study, we conducted a one-way Analysis of Variance (ANOVA). The one-way ANOVA test was appropriate because our predictor was categorical with more than two groups, and our interest was in comparing group means while controlling the familywise error rate via a single omnibus test.

Formally, the null hypothesis states that mean ASK scores are equal across the first, second, third, and fourth year of high school, while the alternative states that at least one

grade-level mean differs. The ASK total score (ranging from 0 to 12) served as the dependent variable, while the students' year of study (first, second, third, or fourth year) was treated as a four-category factor. We first examined the number of correct answers and the most common responses for each of the 12 questions. We evaluated the distribution of student scores (from 0 to 12 points) and performed a performance stratification analysis to classify students into distinct groups. Then, we applied a one-way ANOVA test to investigate the influence of the high school year on students' success in the ASK test.

We used Microsoft Excel (Microsoft 365) to organise the dataset so that each student's total score was calculated and assigned to the appropriate grade-level group, after which the one-way ANOVA procedure was applied to these four groups. The primary result was the F-statistic with its degrees of freedom and *p*-value, alongside the group means and standard deviations, to assess whether ASK performance varies across years of study under the standard assumptions of one-way ANOVA.

To compare the success of participating students in each of the three sustainability domains for H2, we calculated the average points earned by a single student in each of the three sustainability domains, as well as the average percentage of all participating students in each domain.

4. Results

Our study employed the revised ASK test [67,68,72] to evaluate students' knowledge of basic sustainability principles. Table 2 provides the ASK survey questions, response options, and the resulting percentages. For each question, participants chose from a single correct answer, two or three incorrect answers, or a "Don't know" option. Answer options were randomised. Table 2 shows the correct answers in bold for reporting purposes. Percentages are rounded to the nearest whole number for readability; totals may not sum to 100% due to rounding.

Table 2. Revised Assessment of Sustainability Knowledge (ASK) questions and answers (N = 297).

Question and Response Options		Percentages
<i>Environmental domain</i>		
1. What is the most common cause of pollution of streams and rivers?		
(a) Surface water running off yards, city streets, paved lots, and farm fields		24%
(b) Dumping of garbage by cities		29%
(c) Litter near streams and rivers		24%
(d) Waste dumped by factories		20%
(e) Don't know		2%
2. Ozone forms a protective layer in the earth's upper atmosphere. What does ozone protect us from?		
(a) Harmful UV rays		84%
(b) Acid rain		9%
(c) Climate change		2%
(d) Sudden temperature changes		2%
(e) Don't know		3%
3. Which of the following is an example of sustainable forest management?		
(a) Never harvesting more than what the forest produces in new growth		67%
(b) Setting aside forests to be off-limits to the public		12%
(c) Producing lumber for nearby communities to build affordable housing		6%
(d) Putting the local communities in charge of forest resources		7%
(e) Don't know		8%
4. Of the following, which would be considered living in the most environmentally sustainable way?		
(a) Reducing consumption of all products		20%
(b) Recycling all recyclable packaging		51%

(c) Buying products labelled “eco” or “green”	23%
(d) Buying the newest products available	1%
(e) Don’t know	5%

Social domain

5. Which of the following is the most commonly used definition of sustainable development?	
(a) Meeting the needs of the present without compromising the ability of future generations to meet their own needs	60%
(b) Creating a government welfare system that ensures universal access to education, health care, and social services	20%
(c) Setting aside resources for preservation, never to be used	4%
(d) Building a neighbourhood that is both socio-demographically and economically diverse	2%
(e) Don’t know	14%

6. Over the past three decades, what has happened to the difference between the wealth of the richest and poorest Europeans?	
(a) The difference has increased	62%
(b) The difference has stayed about the same	18%
(c) The difference has decreased	5%
(d) Don’t know	15%

7. Which of the following populations has the highest rate of growth?	
(a) Africa	31%
(b) North America	10%
(c) Europe	7%
(d) China	42%
(e) Don’t know	10%

Economic domain

8. Which of the following is the most commonly used definition of economic sustainability?	
(a) Long-term profitability	56%
(b) Maximizing the share price of a company’s stock	7%
(c) When costs equal revenue	11%
(d) Continually expanding market share	9%
(e) Don’t know	18%

9. Which of the following countries is the largest emitter of the greenhouse gas carbon dioxide?	
(a) China	37%
(b) U.S.	26%
(c) Brazil	7%
(d) Japan	4%
(e) Don’t know	26%

10. Which of the following is a leading cause of the depletion of fish stocks in the Atlantic Ocean?	
(a) Fishermen seeking to maximize their catch	21%
(b) Reduced fish fertility due to genetic hybridisation	13%
(c) Ocean pollution	38%
(d) Global climate change	11%
(e) Don’t know	18%

11. Which of the following is the best example of environmental justice?	
(a) All stakeholders from an indigenous community are involved in setting a quota for the amount of wood they can take from a protected forest next to their village	46%
(b) Urban citizens win a bill to have toxic wastes taken to rural communities	12%
(c) The government dams a river, flooding nature protection areas to create hydro-power for large cities	10%
(d) Multi-national corporations build factories in developing countries where environmental laws are less strict	4%
(e) Don’t know	28%

12. Put the following list in order of the activities with the largest environmental impact to those with the smallest environmental impact:

- A. Keeping a cell phone charger plugged into an electrical outlet for 12 h.
- B. Producing one McDonald's quarter-pound hamburger.
- C. Producing one McDonald's chicken sandwich.
- D. Flying in a commercial airplane from Washington D.C. to China.

(a) D, B, C, A	33%
(b) A, C, B, D	17%
(c) D, A, B, C	23%
(d) D, C, B, A	16%
(e) Don't know	11%

Across the twelve ASK questions, students demonstrated a mixed pattern of sustainability knowledge, with several domains showing strong recognition of core concepts and a smaller set of misconceptions. In the environmental domain, only a minority correctly identified diffuse runoff as the most common source of stream and river pollution, while a larger share attributed pollution to municipal dumping. On the other hand, ozone's protective function against harmful ultraviolet radiation was widely understood, with a large majority selecting the correct response, and sustainable forest management was also reasonably well grasped, as most students chose the option that caps harvests at or below new growth. However, when asked to judge the most sustainable lifestyle choice, a majority favoured recycling over reducing overall consumption, indicating a familiar "recycling bias" in which downstream waste handling is overemphasised relative to upstream demand reduction.

In the social domain, most students selected the commonly used Brundtland definition of sustainable development, suggesting that the headline concept is broadly known. They also tended to recognise that income or wealth disparities between the richest and poorest Europeans have increased in recent decades, which aligns with major statistical series and media narratives. Yet population dynamics proved more problematic: although global demographic data consistently show the highest population growth in Africa, the modal response was China. This misperception likely arises from absolute population size, economic prominence, or media visibility with growth rates.

In the economic domain, over half of students chose "long-term profitability" as the most common definition of economic sustainability, which reveals a prevalent firm-centric understanding that risks narrowing the concept to financial viability rather than maintaining productive, human, and natural capital over time. More than one-third of students correctly identified China as the largest emitter of carbon dioxide, with substantial minorities distributing responses between the United States and "don't know," which is consistent with the complexity of comparing current emissions, historical responsibility, and per capita metrics. Furthermore, the leading driver of declining fish stocks is overfishing, but most students have selected ocean pollution, indicating a tendency to attribute environmental degradation to generalised pollution rather than sector-specific extraction pressures. In contrast, the environmental-justice item was handled well, with the largest share recognising inclusive, community-based quota setting as the best example, suggesting sensitivity to procedural fairness and indigenous rights within resource governance. In the last question, the correct order was the most frequently selected, yet a substantial portion still misranked the trivial energy draw of a plugged-in charger ahead of food or aviation impacts.

Table 3 summarises the distribution of ASK test scores. The average score (mean) was 5.4 out of 12 points, indicating that student performance was generally below the mid-point of the scale. The standard deviation was 2.81, showing a moderate spread of scores

around the mean. In other words, while some students performed well, a significant number scored much lower. The median was 5, and the most frequent score (mode) was 4 points, achieved by 58 students, representing 19.5% of all participants. The highest concentration of scores was in the lower range, with 44.1% of students scoring 4 points or less. In contrast, only 13.5% of students scored 9 points or more, indicating that high achievement was relatively rare.

Table 3. Student performance distribution based on knowledge scores (N = 297).

Points	Frequency	Percentages
12	13	4.4%
11	7	2.4%
10	8	2.7%
9	12	4.1%
8	24	8.1%
7	31	10.4%
6	32	10.8%
5	39	13.1%
4	58	19.5%
3	31	10.4%
2	25	8.4%
1	11	3.7%
0	6	2.0%
Σ	297	100%

Based on a performance stratification analysis (Figure 1), students were categorised into distinct groups according to their scores. We used a quartile approach to analyse the score distribution and classify students into four performance tiers (Figure 1): low performers (0–3 points), medium performers (4–6 points), high performers (7–9 points), and top performers (10–12 points). As shown above, the distribution is slightly right-skewed (mean > median), with relatively few very high scores. Grouped shares by bands were 0–3 = 24.58%, 4–6 = 43.43%, 7–9 = 22.56%, and 10–12 = 9.43%. Quartiles were Q1 = 4, Q2 (median) = 5, and Q3 = 7 (IQR = 3), indicating that the middle 50% of students scored between 4 and 7 points. Overall, the profile reflects moderate performance, with most students clustered around 4–6 points and a comparatively small upper tail of high performers.

To test hypothesis H1, we have assessed whether ASK performance varies across years of study under the standard assumptions of one-way ANOVA. Summary data and results of the F-statistic are presented in Tables 4 and 5, rounded to two decimal places for clarity.

Table 4. Descriptive statistics by study year for testing hypothesis H1 (N = 297).

Year of High School	Frequency	Average	SD
First year	52	5.83	2.49
Second year	41	5.12	2.45
Third year	82	5.01	2.97
Fourth year	122	5.57	2.93

Note: SD = Standard Deviation.

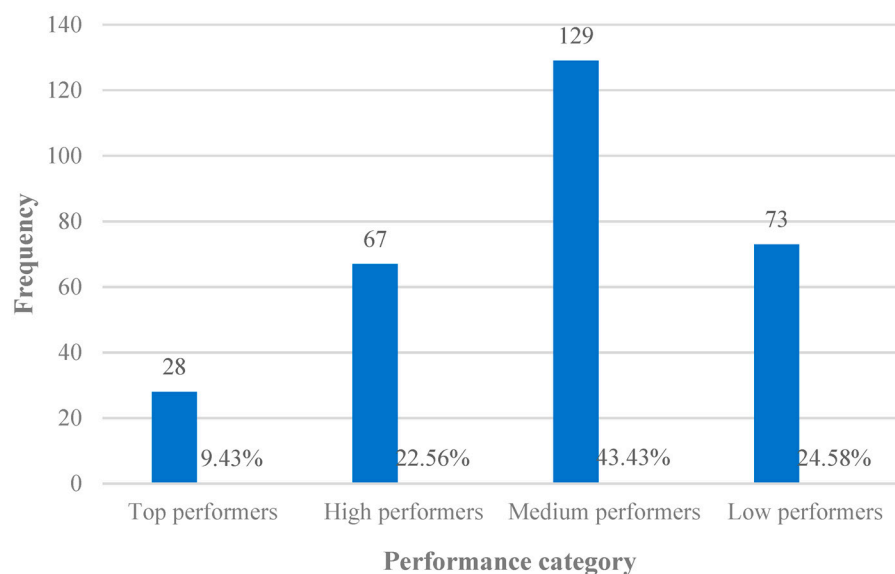


Figure 1. Stratification of sustainability knowledge by performance category (N = 297).

Descriptively, mean scores ($\pm$ standard deviation) were 5.83 (2.49) in the first year, 5.12 (2.45) in the second, 5.01 (2.97) in the third, and 5.57 (2.93) in the fourth (Table 4). Although the pattern suggests a slight “U” shape (with somewhat higher means in the first and fourth years and lower means in the second and third), the omnibus test was not significant.

Table 5. One-way ANOVA results for hypothesis H1.

Source of Variation	SS	df	MS	F	p-Value	F Crit
Between Groups	28.32	3	9.44	1.20	0.31	2.64
Within Groups	2310.80	293	7.89			
Total	2339.12	296				

Note: SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square.

As shown in Table 5, a p -value of 0.31 is greater than the typical alpha level of 0.05. Therefore, we fail to reject the null hypothesis (H1) that grade-level means are equal and cannot support our hypothesis H1 stating that the year of high school affects students’ success in solving the ASK test.

To complement the non-significant omnibus one-way ANOVA, we additionally computed effect sizes. Based on the sums of squares reported in Table 5, the effect size measures were as follows: $\eta^2 = 0.012$ and $\omega^2 = 0.001$. Eta-squared (η^2) indicates a very small effect, consistent with the non-significant F-test. Omega-squared (ω^2) confirms a near-zero estimated population effect size.

To improve interpretability, we also report 95% confidence intervals for group means (calculated using the group standard deviations and sample sizes):

First-year students: $M = 5.83$, 95% CI $\approx [5.15, 6.51]$.

Second-year students: $M = 5.12$, 95% CI $\approx [4.34, 5.90]$.

Third-year students: $M = 5.01$, 95% CI $\approx [4.37, 5.65]$.

Fourth-year students: $M = 5.57$, 95% CI $\approx [5.05, 6.09]$.

The overlapping intervals are consistent with the trivial effect size and the non-significant omnibus one-way ANOVA result.

The 12-item scale demonstrated good internal consistency, with Cronbach’s $\alpha = 0.837$. Item difficulty values ranged from $p = 0.39$ to 0.88, and corrected item–total correlations ranged from $r = 0.29$ to 0.65, indicating acceptable discrimination across items. Residual

normality and variance homogeneity were checked. Assumption checks for residual normality and homogeneity of variances indicated no violations that would affect the validity of the parametric analysis. A nonparametric Kruskal–Wallis test was conducted as a robustness check and led to the same pattern of results, confirming that the findings were stable across alternative analytical approaches.

To provide a comparison for H2, which states that knowledge in the economic domain of sustainability is more limited than knowledge in the environmental and social domains, we calculated the average points earned by a single student in each of the three sustainability domains, as well as the average percentage of all participating students in each domain.

A comparison of the three studied domains of sustainability knowledge, the environmental, social, and economic domains (Table 6), reveals that students are underprepared in all three. Nonetheless, they have a more profound understanding of the social (average 51%) and environmental domains (average 49%), while the knowledge of the economic domain (average 38%) lags far behind.

Table 6. Student performance in each sustainability domain based on knowledge scores (N = 297).

DOMAIN	MAX POINTS	AVERAGE POINTS	AVERAGE %
Environmental	4	1.95	49%
Social	3	1.53	51%
Economic	5	1.92	38%

To test H2, we first calculated domain-specific percentage scores for each student (correct answers divided by the number of items in that domain). Given the ordinal, bounded, and non-normally distributed nature of domain percentages, differences across domains were examined using a Friedman repeated-measures test. The test indicated a statistically significant domain effect, $\chi^2(2) = 49.91$, $p = 1.45 \times 10^{-11}$, with a small but reliable effect size (Kendall's $W = 0.084$).

Post hoc Wilcoxon signed-rank tests with Holm adjustment showed that students scored significantly lower in the economic domain compared to both the social domains ($Z = 6.51$, $p_{\text{adj}} = 2.30 \times 10^{-10}$, $r = 0.38$) and environmental domains ($Z = 5.92$, $p_{\text{adj}} = 6.39 \times 10^{-9}$, $r = 0.34$). The comparison between the environmental and social domains was not statistically significant ($Z = -0.44$, $p_{\text{adj}} = 0.662$, $r = 0.03$).

Descriptively, performance was highest in the social domain ($M = 51.07\%$, Median = 33.33%), followed by the environmental domain ($M = 48.65\%$, Median = 50%), while the economic domain lagged behind ($M = 38.38\%$, Median = 40%). These results confirm H2 and highlight a clear weakness in students' economic sustainability knowledge.

5. Discussion

The findings suggest that, in the sample presented, the year of high school is not a meaningful determinant of ASK outcomes; any observed mean differences are small and unstable. We therefore found that high school students in BiH do not show significant differences in sustainability knowledge across different years of study (H1). The one-way ANOVA (H1) indicated no statistically significant differences in ASK performance across different years of study among high school students from BiH in our sample. While the total sample size ($N = 297$) is adequate, the very small effect sizes imply that substantially larger and more balanced groups (or models including additional covariates, such as study track, prior coursework, or motivation) would be required to detect subtle grade-related differences with adequate power. The distribution of achieved scores shows a right-skewed pattern, with a large number of students scoring in the lower range. The moderate standard deviation supports that while there is some variation in performance,

the majority of students clustered around the lower scores. Moreover, the results indicate that knowledge in the economic domain (H2) lags the most compared to the social and environmental domains. We further discuss these findings from three perspectives: the theoretical and regional context, the practical and pedagogical implications for sustainability education, and the study's limitations.

5.1. Findings in Regional and Theoretical Perspective

Understanding these findings necessitates placing them in the context of regional sustainability education. The comparisons with studies conducted in the regional context of BiH and neighbouring countries [26], particularly in the Balkan region, contribute to a comprehensive analysis and reinforce the regional case that we strive to present. Despite the limitations imposed by our study's lack of sample representativeness, these comparisons hold substantial importance.

In contrast, Fošner's [76] previous research, which applied the ASK test to Slovenian higher education students, showed not only that postgraduate students and final-year undergraduates are much more knowledgeable than first- and second-year students, but also that natural science students rank first in sustainability knowledge, followed by social science students and technology students. Given that Fošner's [76] study was conducted at the tertiary level [16], which differs from the secondary level of our study, the comparison may be more indicative than direct.

The research by Cvetković et al. [60], who conducted research at the tertiary level of education in two other Western Balkan countries, Montenegro and North Macedonia, comparing items related to environmental awareness, knowledge, and safety, also found that the selected individual items constituting these constructs are influenced by gender, age, and the year and rate of study. Although their models showed overall low explanatory power, their study supported the role of demographic, cultural, social, economic, and local contexts in shaping attitudes, beliefs, knowledge, and awareness.

Previous studies, such as Djurić [27], indicate that the educational sector and other sectors in BiH must implement additional and more effective actions because the measures taken so far have not achieved the desired impact on sustainability knowledge and awareness, which remains insufficient and requires improvement [28]. Pojani and Grabova [59] advocate for educational reforms to enhance support for sustainability initiatives. Based on a measurement instrument that relies on statements in accordance with sustainable development goals, Vukadin and Mladenović [29] found that knowledge of sustainability and the SDGs in BiH and Croatia is intermediate and therefore requires improvement. Andić and Tatalović Vorkapić [26], in comparison, focus on norms, awareness, and responsibility related to sustainability practices in the region.

Our findings are almost completely consistent with the aforementioned studies conducted in BiH. Based on this, we believe that various actions are needed to enhance sustainability education, including additional research to identify why the progression through high school does not translate into measurable gains in sustainability knowledge.

The comparison of the environmental, social, and economic domains of sustainability (H2) shows that students have better knowledge in the social domain, followed by the environmental domain, while their knowledge in the economic domain lags the most. Therefore, our findings align with previous research indicating that while all three domains are interconnected, the economic domain requires attention comparable to that given to the environmental and social domains, as there is a need to enhance knowledge in the economic aspect of sustainability. Namely, Popović and Nedelko [92] found that students in BiH and Croatia prioritise a social domain, followed by ethical behaviour, environmental care, and economic welfare. They suggest and encourage higher education institutions and other organisations to align their strategic orientation with socially

responsible corporate practices [92]. Višnjić-Jevtić et al. [66] investigated how teachers understand sustainable development, the importance of education for sustainability, and the teachers' assessment of sustainability-orientated programmes implemented in preschool education. They say that to improve sustainability education, all three domains of sustainability need to be given balanced attention. It is especially important to enhance teachers' understanding and include the economic domain alongside the environmental and social domains. They base their research on the adapted OMEP [93] rating scale of the domain of sustainability, which was later also adapted by Vodopivec and Šindić [65] and Šindić et al. [64]. However, it has to be considered that the findings of Višnjić-Jevtić et al. [66], Šindić et al. [64], and Vodopivec and Šindić [65] are based on teachers' assessments. Vodopivec and Šindić [65], who similarly focused their research on the outcomes of holistic sustainability education in early childhood, found that the children who participate in such programmes are much more likely to behave in a more environmentally friendly manner, are more engaged in ecological and economic sustainability activities, and generally achieve better outcomes in sustainability [65]. Importantly, their research emphasises the holistic approach which addresses all three domains of sustainability. Continuing from this, Šindić et al. [64] provide an in-depth analysis that shows that activities that involve local communities and are part of everyday situations in preschool education are very effective in promoting favourable environmental as well as social and economic attitudes. Based on our findings, we can only agree with the previously mentioned research that advocates for holistic sustainability education across all three domains.

5.2. Practical and Pedagogical Implications for Sustainability Education

The results suggest a need for further support or review of the ASK test content and teaching strategies, methods, and approaches to improve overall student outcomes. The misconceptions we identified in our study shed light on the areas and topics that require more comprehensive attention during education. Moreover, these misconceptions provide valuable insights for developing appropriate sustainability practices and instructional approaches that educators can adopt in the future to customise sustainability education curricula and enhance sustainability knowledge. Based on these, we suggest that teachers put more emphasis on topics such as different pollution sources and their impact, population growth rates, and the importance of demand consumption in sustainability. We suggest including targeted reinforcement of systems and orders-of-magnitude reasoning, clearer differentiation between drivers and symptoms, and explicit framing of sustainability trade-offs using comparative baselines and life-cycle perspectives.

Teacher training could rectify potential deficiencies in understanding sustainability concepts and guide educators on how to incorporate all three sustainability domains, as the integration of economic factors is frequently perceived as particularly challenging. But most of all, it would contribute to the teachers' professional development and the implementation of effective teaching strategies and approaches such as life cycle thinking, systems thinking [81], order-of-magnitude estimation, data literacy modules, and the like. The examples of learning methods aimed at achieving SDGs [19] provide insightful ideas for practical application, such as "experiment with renewable energy technologies" or "conduct an energy-saving campaign," and inform the design of their sustainability training. The OMEP [93] rating scale and other measurement instruments and frameworks could provide further ideas to teachers designing the optimal content and approaches for specific sustainability training.

The active learning approaches and hands-on activities, such as implementing a school-wide recycling programme and conducting energy audits, could encourage engagement and results. In designing the most effective training, educators need to apply integrative thinking, envision changes, and achieve transformation as suggested by the

UNECE's [81] sustainability competence model for educators. To enhance the integration of the economic aspect in sustainability curricula, educators could assign projects focused on the product lifecycle, encompassing production to disposal, emphasising environmental, social, and economic impacts.

We advocate for schools to incorporate sustainability education into the curricula at an early stage. For instance, eco-programmes emphasising recycling, energy conservation, and community engagement could be instituted in preschools, while sustainability education in primary schools should be introduced with age-appropriate content to establish foundational knowledge.

5.3. Limitations

We have to point out the limitations of our study. It employs a cross-sectional design in one country. Although most participants in the study attended economic high schools, some attended technical and other vocational high schools, which presents the possibility of intra-school type correlation, with students being nested within different types of schools (economic vs. technical). However, information on the specific schools attended by participants was not collected, which precludes the use of multilevel modelling or cluster-robust standard errors at the school level. The absence of significant differences across years of study further suggests that unobserved clustering effects may be limited, although they cannot be fully excluded. As mentioned, the majority of the students who participated are the third- or fourth-year students of economic high schools from the same region. This limitation constrains our ability to conclude the causality and generalisability of the findings. The ASK test is multiple-choice, and thus, we may not capture deeper reasoning or domain-specific competencies. Our results might also suggest a need for further review of the ASK test content. Moreover, we relied on a single omnibus test (one-way ANOVA) without including other factors such as school track, prior courses, or teacher effects. We also acknowledge that future research should include more rigorous methods to validate the differences in knowledge levels across sustainability domains that our data strongly suggest exist.

6. Conclusions

The contribution of our article lies in addressing sustainability challenges within the specific regional context of BiH, highlighting the challenges and characteristics of sustainability education in the region.

Firstly, by conducting the first empirical analysis based on the revised ASK measurement instrument tailored to the BiH context, we provide a knowledge-based measurement that was compared to measurements based on awareness, attitudes, or competencies in previous studies. In line with this, we assessed the high school students' sustainability knowledge in BiH using the revised Assessment of Sustainability Knowledge (ASK). The results of the ASK test showed an average score indicating moderate but generally below-midpoint knowledge. The results also suggest that the year of high school does not meaningfully determine ASK outcomes, meaning that progression through high school alone does not translate into measurable gains in general sustainability knowledge.

Further, based on misconceptions, we identified the topics that require more comprehensive attention during the education. The thorough analysis shows that students demonstrated solid knowledge of emblematic concepts such as strong recognition of ozone protection, the Brundtland definition of sustainable development, current global emitters, and procedural justice. On the other hand, misconceptions cluster around diffuse processes (non-point pollution), relative impact magnitudes (consumption vs. recycling; flights and food vs. plug loads), sector-specific drivers (overfishing vs. pollution), and rate-level distinctions in demography. Particularly notable misconceptions include a

recycling-centric bias in judging “sustainable” behaviours and confusion about global demographic trends. Performance stratification further revealed that nearly two-thirds of students scored 6 points or less, underscoring gaps that curricula could address more directly. Placing these findings within the current context of sustainability education in BiH suggests that various actions are needed to enhance sustainability education and teaching strategies to improve student outcomes.

Secondly, our study evaluates the portrayal of the social, environmental, and economic sustainability domains. Students demonstrated more knowledge in the social and environmental domain compared to the economic sustainability domain, which lags behind. These findings call for a more balanced approach in sustainability education that addresses not only the social and environmental but also the economic domain of sustainability holistically.

Finally, we build a valuable regional case by providing an analysis of sustainability awareness, the environmental situation, and sustainability education in BiH and offer practical implications for curriculum development, particularly relevant for transitional education systems. Our results suggest that teaching should move beyond basic awareness. Lessons can focus on real impacts (for example, life-cycle thinking), common misconceptions, and practical choices. Future work should test classroom interventions with pre- and post-tests, include more background factors, use item-level analysis to improve the test, follow students over time, and compare results across regions. Sustainable education should holistically address the environmental, social, and economic domains of sustainability to achieve better outcomes. Taken together, these steps can move sustainability education beyond awareness toward robust, transferable knowledge and action-orientated competencies.

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Institutional Review Board Statement: Our study is governed by the Scientific Research and Innovation Activities Act (Zakon o znanstvenoraziskovalni in inovacijski dejavnosti—ZZrID, Official Gazette of the RS, No. 186/21 and 40/23). According to Slovenian national standards, mandatory ethics committee approval is primarily required for clinical trials, invasive medical research, or studies involving vulnerable groups where high risk is present. For non-invasive, anonymous social science surveys involving professional adult populations, the decision-making falls under the jurisdiction of the individual research institution’s ethical framework. The study was conducted in accordance with the Rules on the Organization and Operation of the GEA College Research Institute (available at: <https://gea-college.si/raziskovalni-institut/> accessed on 21 December 2025). These internal guidelines stipulate that formal ethical review is not mandatory for research that: (a) is entirely anonymous, (b) is non-invasive, and (c) does not collect sensitive personal data as defined by the GDPR. As our study strictly followed these criteria, it qualified for an exemption from a formal IRB review.

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Abbreviations

The following abbreviations are used in this manuscript:

ANOVA	Analysis of Variance
AQI	Air quality index
ASK	Assessment of Sustainability Knowledge
BiH	Bosnia and Herzegovina
COP30	Climate Change Conference
EEA	European Environment Agency
SD	Standard deviation
SDG	Sustainable development goals
WHO	World Health Organization
UN	United Nations

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