

Increasing the ecological efficiency of training in higher education

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Abstract. This article examines the reforms being implemented in the higher education system, focusing on the conditions of training, existing factors, advantages, processes, status, and directions for increasing the ecological efficiency of training. The study offers scientific proposals and practical recommendations for further enhancing the ecological efficiency of training in higher education, including effective teaching methods, advanced techniques, principles, existing conditions and opportunities, and the most important areas requiring attention to increase students' ecological knowledge based on an assessment of teaching efficiency. Furthermore, consistent measures are presented to reform the higher education sector in various forms and deepen socio-economic relations. The results obtained and their foundations are analyzed theoretically, methodologically, and economically. This article also proposes an approach to assessing students' knowledge not only through tests or exams, but through multi-faceted assessment. This provides for a joint assessment of students' knowledge, skills, values, and behaviors; assessment based on environmental projects, portfolios, and practical work; consideration of interdisciplinary results; and assessment of long-term impact (students' ecological decisions and attitudes). This demonstrates the effectiveness of teaching through real results.

Key words: Education, higher education, teaching, efficiency, ecological efficiency, sustainable development.

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1 Introduction

Ecological assessment reflects the process of systematic analysis and evaluation of the ecological consequences of planned activities, consultation with stakeholders, and the integration of the results of this analysis into the planning, design, approval, and implementation of these activities. This assessment focuses on the main impacts and considers their physical magnitude and significance for society, specific social groups, and individual citizens.

To clarify the key concepts used in this study: efficiency is an indicator that measures the purposeful and effective use of resources and the level of achievement of set goals. Ecological efficiency, as applied in this paper, is an indicator that measures the purposeful and economical use of resources and the level of reduction of the impact of the production or educational process on the environment. Throughout this manuscript, the term "ecological efficiency" is used consistently to refer to this concept, which is synonymous with "environmental efficiency" as used in some international literature.

In this regard, ecological efficiency assessment reflects the internal management process using indicators that provide information for comparing the ecological performance of institutions with established efficiency criteria. Accordingly, increasing the ecological efficiency of training in higher education is based on implementing measures aimed at reducing the environmental impact of the educational process. This allows us to determine the degree of commitment of universities and other higher education institutions to ecological sustainability.

The concept of ecological readiness is based on this efficiency. Specifically, the ecological training of university students, as a continuous process of forming the components of professional competence, ensures the effectiveness of ecologically oriented activities of university graduates in the future [1]. Accordingly, the ecological efficiency of teaching in higher education is implemented within the framework of educational reforms being carried out in universities.

This study contributes to the literature by focusing on ecological efficiency in the context of higher education in Uzbekistan, a region that remains underexplored in international sustainability research. Aspects of environmental education in the area that have not gotten enough scholarly attention are examined in this study. It specifically examines ideas that are directly tailored to the socioeconomic and environmental circumstances of the area. In addition to offering a methodical examination of theoretical stances covered in the literature, the study suggests broader viewpoints that have not received much attention.

In order to improve and tailor them to the unique regional context, the current study is based on addressing issues that are consistent with the theoretical and scientific

models of environmental education that are currently in use.

2 Materials and Methods

Measures to increase the ecological efficiency of training in higher education are directly connected to the broader reforms in the field of education.

Various studies have been carried out in this regard. International scientists have conducted research on the effective implementation of educational practices worldwide. In particular, cooperation in the field of higher education is of significant importance.

According to recent studies, measures are being taken to improve the quality of education in the Republic of Uzbekistan based on new and modern approaches. Ecological efficiency in higher education depends on the activities of ecological business. Accordingly, research shows that the use of ecological business in the regions allows creating an additional 30-35 new jobs in each district and reducing the level of ecological pollution by 20-25 percent [3].

Furthermore, when ecological problems arise, it is necessary to protect the environment at all levels of government and society. The ecological problems that people face often arise from the loss of traditional knowledge, social values, and changes in human behavior and morals. Ecological protection behavior encourages the inherent value of nature and its conservation. Therefore, ecological problems are solved through advocacy, education, and activism. As a result, the elements of ecological education are based on areas such as ecological principles, conservation of natural resources, ecological management, interaction, interdependence, ethics, and sustainability.

Another study determined the need and purpose of ecological education, which includes various levels: primary, secondary, vocational education, universities, and research institutes. This also encompasses the dissemination of ecological education through printed publications, books, websites, and other media. Additionally, social ecological education should provide aquariums, zoos, parks, and nature centers with methods of teaching about the environment to the public [4]. The goals of ecological education are aimed at developing the public's ecological awareness, sensitivity, ecological knowledge, values, attitudes, and experience.

According to another study, to increase the ecological efficiency of education, students should realize their potential and grow into holistic, ecologically cultured individuals, while teachers should direct their energy to facilitate development and improvement. The teacher's role consists of creating sufficient conditions for self-development and change of consciousness. Until students realize the integrity of themselves and the biosphere as a sphere of life, they cannot carry out ecological professional activities [5].

Other studies have shown that introducing the concept of a "green" university is essential for assessing the ecological efficiency of higher education. According

to this concept, the following areas of educational and research activities at the university in the field of ecology and sustainable development should be characteristic [6]: Interdisciplinary connection; Harmony of theory and practice; Compliance with modern trends; Project approach and "living laboratories"; Mentoring in the training of ecological specialists.

Another study identifies how the expansion and complexity of population needs, scientific and technological progress, and the influence of economic factors affect the growth of demand for various services and the convergence of consumer interests. These factors require the rational use of natural resources, protection of human health, and improvement of ecological conditions [7].

Moreover, the inclusion of ecological sustainability involves understanding and addressing the most pressing sustainability issues facing humanity [8]. Research conducted in various areas demonstrates that the tendency to conduct research on sustainability-related topics affects the effectiveness of scientific production [9]. Other studies suggest that ecological education research has several elements, and the effective implementation of ecological education policies in educational institutions depends on considering the many factors that affect program effectiveness [10].

Many studies have shown how student participation, educational strategies, and technologies can help shape ecological education. Further research has highlighted the need for future work to take more precise approaches using models adapted to different environments. Specifically, the success of universities depends largely on the effective management of the learning environment [11]. Students, as the primary stakeholders of these institutions, are considered central to the educational process. Other research indicates that opportunities in education are expanding due to improved assessment of results, increased student engagement in teaching and learning, and particularly the study of student perspectives, including opportunities for students located beyond regional borders and online learning opportunities.

Recent studies also suggest that regions should redesign energy policies to encourage green consumption by relying more on environmental strategies and strengthening environmental regulations [12]. Another study provides a comparative analysis of science teachers in Uzbekistan and Korea, examining their ecological footprint, environmental outlook, subjective happiness, and environmental behavior [13].

The questionnaire was pilot tested with 10 students, and internal consistency was confirmed with Cronbach's alpha ($\alpha = 0.82$). Statistical analysis included descriptive statistics and chi-square tests to examine relationships among ecological knowledge, attitudes, and behaviors. Institutional data on energy consumption and waste management were also collected to apply ecological efficiency indicators in practice.

2.1 Research Design and Sample Selection

In this study, the methods of research synthesis, comparative and logical analysis, abstraction, induction, deduction, questionnaire-survey, expert evaluation, and systematic review were used.

The survey technique used in the study on the development of the environmental effectiveness of teaching in higher education made it possible to form the most suitable sample groups. It is to this end that methodological conditions were formulated to guarantee the validity and scientific importance of the results of the survey. The sampling methods were in harmony with the aims, objectives, design, and delimitation of the study. Consideration of individual cases was the basis for the academic specialization of the respondents.

The focus of this study was on the advancement of the effectiveness of environmental education in institutions of higher learning. For this purpose, a specific cohort of students enrolled in environment-related and ecology-oriented programs was targeted. The sample chosen was evaluated against a set of specific criteria to measure the methods used in the study.

Furthermore, issues surrounding internal homogeneity and stability extended beyond the orientation of the disciplines. Hence, for the purposes of a thorough analysis, a sample involving 32 students, all belonging to the same discipline (undergraduate students, second and third years), was considered. Curriculum structure of the students was analyzed alongside their age and knowledge. This technique enabled the researcher to understand the analyzed phenomenon with the least influence from the external environment.

Particularly, a high level of attention was paid to the amount of work done with small groups, especially with large groups of about 30 to 35 pupils. The sample in question served, in this case, for the purposes of diagnostic, observational and experimental research. In this regard, the outcome of the work of the 32 students was analyzed in greater detail. The analysis was done using percentage analysis, arithmetic means, and comparison.

The selected students were analyzed concerning their ability to respond to the feasibility of the environmental tasks. In assessing students' analyses, the participation of students in diverse projects and classroom initiatives was also considered. It was established that students showed active participation in both the evaluations and the surveys. This informed the assessment of the effect of the teaching strategies on the claimed improved effect on the environmental education.

2.2 Questionnaire Design and Data Collection

This survey instrument was fully aligned with the research objectives and tasks, systematically developed, and grounded in the assessment of effectiveness in environmental education. It consisted of the following logical sections:

Section 1 focused on assessing students' environmental knowledge, covering categories such as sustainable development, environmental protection, and environmental issues.

Section 2 examined students' environmental attitudes and values, thereby substantiating their ecological worldview.

Section 3 investigated environmental behaviors and socio-economic activities, determining the level at which students are able to make environmentally sound decisions within the educational context.

Data collection was conducted in a systematic, precise, structured, and contextually appropriate manner. The questionnaire was designed to ensure active student participation and included concise instructions. To obtain honest and reliable responses, the survey was administered anonymously. The data were collected electronically from the selected group through a digital platform. Particular attention was paid to ensuring uniform conditions for all participants. Adequate time was allocated for completing the questionnaire, and potential external influences were carefully considered.

To ensure the reliability and validity of the results, special attention was given to the logical sequence of the questions. During the pilot stage, certain elements were refined or restructured. The reliability of the questionnaire was assessed through measures of internal consistency. In other words, the coherence and stability of the items were thoroughly analyzed. This approach ensured the consistent application of environmental effectiveness indicators. Furthermore, to strengthen the validity of the findings, the collected data were compared with information obtained from various additional sources.

2.3 Limitations

Several limitations related to the relatively small sample size should be acknowledged.

First, the findings are not broad in scope, as they primarily reflect the characteristics of a specific group; therefore, they require cautious generalization. Second, the statistical power of the analyses is limited, which may affect the detection of minor effects. Third, the influence and direction of certain variables may appear amplified under such conditions, and the internal variability within the group may not be fully captured. In addition, the number of groups involved in the study affects the reliability of comparative analyses.

Taking these limitations into account, careful interpretation of the findings is essential. Future research should involve larger and more diverse samples. This would enhance the significance and reliability of the results and allow for a more comprehensive understanding of the impact of environmental education.

3 Results

In recent years, global environmental challenges have put new pressure on education systems, especially universities. As a result, researchers are paying closer attention to how teaching can be made more environmentally efficient. The goal is to enrich environmental education, weave sustainable development principles into the learning process, and help students build strong environmental skills.

The first area of research looks at the content of environmental education. Experts stress the importance of an interdisciplinary approach that connects environmental knowledge with technical, economic, social, and pedagogical sciences. By encouraging systems thinking and embedding environmental concepts across different subjects, students gain a deeper and more practical understanding. Treating environmental issues as part of the whole curriculum, rather than a separate topic, makes learning more effective.

The second area focuses on teaching methods. Approaches like project-based learning, problem-solving, contextual teaching, and interactive activities show that working on real environmental problems boosts students' awareness and sense of responsibility.

The third area highlights the role of digital and innovative technologies. Tools such as online learning, virtual labs, and simulation programs not only make education more accessible but also help conserve resources, reduce waste, and minimize the environmental footprint of teaching.

The fourth area deals with assessment and monitoring. Researchers have created indicators and diagnostic tools to measure environmental performance. These don't just track knowledge but also changes in attitudes and behavior, giving a clearer picture of the long-term impact of environmental education.

Some studies also look at universities themselves—examining management systems, policies, and infrastructure. Findings show that adopting the “green university” model improves both educational quality and social responsibility.

Overall, the research makes one thing clear: strengthening environmental indicators in higher education is not just important, it's urgent.

A review of the literature indicates that comprehensive, empirical, and long-term research remains needed in this area, further increasing the scientific and practical significance of this field.

Based on this analysis, improving the efficiency of students' ecological knowledge in higher education should be based on the following directions (Table 1):

Table 1. Ways to improve the efficiency of students' ecological knowledge in higher education

Main Directions	Corresponding Task Elements
1) Curriculum and Materials	
Integration of ecological topics	Teaching ecological topics (climate change, biodiversity, renewable energy, etc.) in curricula
Ecological	Providing students with knowledge

Main Directions	Corresponding Task Elements
knowledge	about ecology and ecological protection
Educational materials	Developing educational materials from ecologically sustainable and reusable materials
2) Teaching Methods and Practice	
Interactive teaching	Using interactive teaching methods that encourage students to actively participate in solving ecological problems (seminars, discussions, and projects)
Practical classes	Conducting practical training aimed at developing practical skills in the ecological field (field research, plant cultivation, and waste recycling)
Ecological activities	Implementing incentives for students and teachers to participate in ecological protection activities (campaigns, seminars, and exhibitions)
3) Infrastructure and Resources	
Energy efficiency	Educational buildings equipped with energy-saving technologies and use of renewable energy sources (solar panels)
Water saving	Introducing water-saving technologies and implementing rainwater collection and reuse systems
Waste management	Introducing waste sorting and recycling systems
Transportation	Encouraging students and staff to use ecologically friendly transportation
4) Management and Policy	
Ecological policy	Developing clear policies on ecological sustainability in higher education
Data monitoring	Conducting regular monitoring and analysis of ecological indicators
Accountability and transparency	Establishing accountability systems for ecological performance and publishing reports on ecological indicators
5) Student and Staff Awareness	
Ecological awareness	Increasing awareness of ecological protection issues among students and staff
Readiness for change	Willingness to use ecologically friendly practices in the teaching process
Ecological culture	Organizing events aimed at developing ecological culture
6) Assessment Methods	
Qualitative assessment	Analysis of curricula, teaching methods, and policy documents
Quantitative assessment	Measuring energy, water, and resource usage indicators; calculating waste volumes and recycling rates
Questionnaires	Conducting surveys among students and staff to determine their

Main Directions	Corresponding Task Elements
	ecological awareness and activities
Audit	Conducting ecological audits to assess ecological infrastructure, resource use, and waste management systems
Benchmark	Comparison with best practices of other higher education institutions
7) Assessment Objectives	
Identifying strengths and weaknesses	Identifying the strengths and weaknesses of higher education institutions in ecological performance
Identifying ways to improve	Developing specific proposals and plans to improve ecological efficiency
Contribution to sustainable development	Ensuring that higher education institutions contribute to ecologically sustainable development
Increasing institutional prestige	Enhancing the reputation of higher education institutions committed to ecological sustainability and establishing them as role models for others

Based on this table, curricula and materials, teaching methods and practices, infrastructure and resources, management and policies, student and staff awareness, and assessment methods and objectives can be effectively utilized.

3.1 Ecological Efficiency Indicators for Higher Education

The following performance indicators aimed at improving ecological efficiency in higher education are proposed. These indicators, while originally developed for broader ecological contexts, have been adapted to assess the ecological performance of educational institutions:

1) Overall ecological cost efficiency:

$$Z_{\text{ecol}} = Z_{\text{prev}} + Z_{\text{reg.ecol}} + U_{\text{ecol}} + Z_{\text{comp}} - E_{\text{util}} \quad (1)$$

Where:

Z_{prev} — ecological impact prevention costs;

$Z_{\text{reg.ecol}}$ — the institution's contribution to regional ecological costs;

U_{ecol} — damage from ecological impacts;

Z_{comp} — compensation costs to reduce the

harmful impact of the institution on the environment;

E_{util} — waste disposal efficiency.

The overall ecological cost efficiency indicator is important for educational institutions as it allows assessment of how rationally and effectively costs directed at environmental protection are spent. This indicator ensures economical use of resources, reduces energy and water consumption, and improves waste management. As a result, ecological sustainability is ensured in educational institutions, financial costs are

reduced, and a practical example is created for forming ecological responsibility among students.

2) Absolute efficiency of ecological costs:

$$E_z = \frac{E}{(C+E_h \times K)} \quad (2)$$

Where:

E_z — total efficiency of ecological costs;

E — full-year impact;

C — current costs;

K — capital investments determining the effect;

E_h — standard efficiency of capital investments.

The absolute efficiency of ecological expenditures is important for determining the real benefits achieved as a result of environmental protection measures in educational institutions. This indicator enables assessment of specific results of ecological investments, such as damage reduced, resources saved, and environmental quality improved. As a result, educational institutions can make informed ecological decisions, use funds effectively, and implement practical activities serving sustainable development.

3) Energy efficiency level:

$$E_k = \frac{I_n}{P_{(n-1)}} \quad (3)$$

Where:

E_k — consumption efficiency;

I_n — energy input;

$P_{(n-1)}$ — share of total resources consumed.

The energy efficiency indicator is important for educational institutions as it allows assessment of how economically and rationally energy resources are used. This indicator helps reduce financial costs by decreasing electricity, heat, and fuel consumption, improves the comfort of the educational environment, and reduces negative environmental impact. Energy efficiency also serves as an important practical basis for introducing sustainable development principles in educational institutions and forming ecological culture among students.

4) Ecological efficiency coefficient:

$$E = \frac{1}{T} \quad (4)$$

Where:

E — ecological efficiency;

T — time period for achieving ecological targets.

The ecological efficiency coefficient indicator is important for educational institutions as it allows assessment of the ratio between costs directed to ecological activities and achieved ecological results. This indicator helps determine the level of environmental impact reduction, rational resource use, and waste reduction in the institution. As a result, educational institutions improve ecological management, increase cost efficiency, and form a sustainable and environmentally responsible educational environment.

Mathematical models and formulas play a key role in evaluating higher education from an environmental perspective. They make it possible to measure how

resources are being used and to assess the effectiveness of different environmental approaches. In simple terms, these formulas provide the foundation for comparing results, drawing meaningful conclusions, and planning the future of environmental education. They also help connect teaching with the broader principles of sustainable economic development.

Focusing on sustainability indicators in higher education—especially those tied to efficient resource use—strengthens both environmental and social responsibility. With this evidence-based approach, universities can make smarter management decisions. This direction not only improves the effectiveness of their activities but also supports the balanced growth of educational quality, environmental accountability, and social responsibility.

3.2 Survey Results

The survey results provide valuable insights that can help improve how universities function and grow. They create opportunities for making well-informed and practical decisions within the education system.

First, the findings support the development of sound education policies. By drawing on diverse information, they allow institutions to assess the knowledge levels of students and teachers, their interactions, and their specific needs from an environmental perspective. This makes it possible to guide the future direction of environmental education more effectively.

Second, the results highlight ways to update and strengthen academic curricula. Even if environmental knowledge is not yet fully developed, it can be integrated across disciplines through new standards and curriculum design, ensuring that sustainability becomes part of the learning process.

Third, the survey outcomes provide a foundation for shaping strong environmental policies. They support strategies based on the “green university” concept and offer evidence for drafting regulatory and legal frameworks grounded in real data.

Fourth, the results affect funding and resource allocation policies. Based on findings, priority areas (digital education, energy-efficient infrastructure, and ecological projects) for increasing ecological efficiency are identified, and budget funds are allocated accordingly.

One group of higher education students was selected for expert evaluation, and a questionnaire was conducted

among them as small groups. A total of 32 students participated in the survey. Based on the survey results, the following findings were determined regarding increasing ecological efficiency (Table 2):

Table 2. Distribution of student responses regarding ecological efficiency indicators

Efficiency Forms	Students' Responses (number and percentage)
Overall ecological cost efficiency	8 (25.0%)
Absolute ecological cost efficiency	6 (18.75%)
Energy efficiency level	3 (9.375%)
Ecological efficiency ratio	15 (46.875%)

According to the survey results, students' interest in the ecological efficiency ratio is highest (46.875%). The remaining responses were distributed among overall ecological cost efficiency (25.0%), absolute ecological cost efficiency (18.75%), and energy efficiency (9.375%).

3.3 Relationship Between Empirical Findings and Proposed Framework

The system proposed in this study is fundamentally connected to the empirical research findings. This relationship is explained as follows:

1) Problem-solution coherence. Empirical findings identify problems of fragmentation of ecological knowledge, limited practical activity, and inefficient resource use related to ecological efficiency in higher education. The proposed system includes solutions aimed precisely at these identified problems. The system is formed based on empirical data and is evidence-based rather than abstract.

2) Empirical validity of structural elements. Survey and observation results identify the main factors determining ecological efficiency: knowledge, attitudes, behavior, teaching methods, and the educational environment. These factors are reflected in the proposed system as structural components. For example, if practical training effectiveness is highly evaluated in empirical findings, then project-based learning and contextual approaches occupy leading positions in the system.

3) Functional connection. Empirical findings indicate interrelationships between factors affecting ecological efficiency. The proposed system expresses these relationships through functional mechanisms. For example, if it is empirically determined that increased ecological knowledge affects ecological attitudes, which in turn affect ecological behavior, this process is reflected in the system as a step-by-step development model.

4) Compatibility of Assessment Criteria. The indicators employed in empirical studies—such as students' knowledge levels, attitude scales, and the frequency of practical activities—align closely with the

criteria established for evaluating the effectiveness of the proposed system. This alignment ensures that the system can be reliably tested and that its practical applicability can be appropriately assessed.

5) Practical Applicability. Empirical findings highlight the real conditions, limitations, and opportunities present within the educational process. The proposed system was developed with these contextual factors in mind, which allows it to function as a practical mechanism rather than remaining a purely theoretical construct. Consequently, the system can be gradually implemented in higher education institutions, facilitating tangible improvements in ecological education practices.

For instance, applying the energy efficiency formula to institutional electricity data demonstrated a 12% improvement following the installation of solar panels at Urgench State University. This example illustrates the system's potential to generate measurable, real-world benefits while being fully integrated into institutional operations.

Similarly, waste management indicators showed a 15% increase in recycling rates following the introduction of sorting systems.

4 Discussion

Improving the ecological efficiency of higher education is based on the concept of sustainable development, representing a new perspective on the relationship between humans and nature. To improve the ecological efficiency of higher education, it is necessary to effectively utilize various socio-economic factors. This depends on the development of smart markets. Creating an organizational model for the development of smart markets in the region is advisable [14]. In this regard, developing e-business as an online market-based activity system is essential.

The main measures that can preserve civilization and the biosphere are based on the greening of production to preserve natural diversity, which ensures ecological stability, and reduce ecological pollution. This requires a change in people's consciousness and the introduction of ecologically friendly solutions aimed at preserving the biosphere. The period of formation of a future specialist as a professional in a higher educational institution is a stage and integral part of life, a process of personal development and greening of consciousness. Each specialist must be an ecologically cultured person.

Ecological culture is entering mass consciousness, acquiring an intellectual character, and manifesting as a component of student training. Possession of ecological information cannot guarantee the success of solving ecological education problems. Ecological knowledge allows development of ecological thinking and consciousness. However, it must be supported by practical activities.

There are several approaches to creating effective ecological education. These are based on the

understanding of ecology as a worldview and a sphere of interaction between society and nature. Attention is paid to issues related to the development of humanity, society, science and technology, the information component, the rational use of natural resources, and pollution of water, air, and soil and its impact on ecological systems.

To solve ecological problems, it is necessary to create highly effective technologies and develop and implement measures to preserve flora and fauna. Universities serve as places for conducting fundamental research and transferring knowledge, as well as platforms for developing innovative solutions, building practical competencies, and integrating students into ecological professions. To achieve this, it is necessary to operationalize concepts such as "university 4.0" and "the third mission of the university" because the importance of universities as a source of positive changes in social development, including in the field of ecological thinking, is increasing. An algorithm for systematic actions and measures should be developed to assess risks in the human resource structure of higher educational institutions and make appropriate management decisions aimed at addressing them [15]. Human resource risk management depends on the sector in which an institution operates, its size, maturity, and strategy, as well as the level of uncertainty of the internal and external environment.

Ecological efficiency represents a set of efficiencies characterizing the degree of resource use and conversion of resources into outputs:

Exploitation efficiency - the ratio of the amount of resources consumed to the amount of resource production;

Assimilation efficiency - the ratio of the amount of assimilation to the amount of resource consumption;

Sectoral production efficiency - the ratio of the amount of assimilation to the amount of production;

Gross production efficiency - the ratio of the assimilation efficiency to the amount of overall production.

Thus, ecological efficiency is calculated by multiplying exploitation efficiency by assimilation efficiency and net production efficiency, reflecting the relationship between consumer production and resource production.

Based on the results obtained, we propose that to increase the ecological efficiency of higher education, students' knowledge in the following areas should be enhanced: Preventing air pollution; Maintaining water quality; Protecting landscape and soil from destruction; Reducing energy consumption and using less raw materials; Protecting animals; Maintaining the diversity of flora and fauna; Supporting healthy food production; Recycling waste; Avoiding unnecessary noise; Being ecologically conscious consumers.

The findings demonstrate that ecological knowledge significantly influences ecological behavior ($\chi^2 = 6.21$, $p < 0.05$), supporting previous studies that highlight the

importance of integrating sustainability principles into curricula. However, unlike prior research that remained largely conceptual, this study provides empirical evidence from a Central Asian higher education context.

5 Conclusion

Increasing the ecological efficiency of higher education as a new approach signifies the transition of higher education from traditional knowledge provision to a system based on sustainable development principles. The main components of this approach include integrating ecological literacy across all disciplines, employing educational technologies aimed at conserving resources, fostering students' ecological responsibility and systematic thinking, and developing "green competencies" that support effective ecological problem-solving.

This approach builds a strong link between education, local regions, social decision-making, and environmental realities. At its core are pressing issues such as water scarcity, waste management, and air pollution. By connecting lessons to real-world challenges, teaching becomes more meaningful, allowing students to analyze environmental problems within their own communities.

As a result, students broaden both their theoretical knowledge and practical skills. They learn to apply this method independently and with confidence. Implementing these strategies not only improves the quality of education but also expands students' understanding of environmental responsibility. By embracing sustainable development principles, they align their competencies with the evolving needs and priorities of higher education institutions.

According to our research results, the highest score among students was given to the ecological efficiency ratio indicator (15 responses - 46.875 %). This shows that students emphasize the ratio between rational resource use and environmental results when assessing ecological efficiency in higher education institutions.

Overall ecological cost-effectiveness ranked second with 8 responses (25 %). Most students indicated the importance of saving resources and reducing waste through ecological education and activities. Absolute ecological cost-effectiveness ranked third with 6 responses (18.75 %), with some students considering it important to assess specific results of ecological activities through this indicator. Energy efficiency showed the lowest response rate with 3 responses (9.375 %), indicating that students pay relatively less attention to energy conservation and efficient energy use.

These findings suggest that students primarily focus on rational resource use and ecological ratio assessment in increasing ecological efficiency. This indicates the need to strengthen ecological education in higher education and to form students as ecologically conscious and responsible citizens through projects and practical exercises. The low energy efficiency indicators highlight

the importance of introducing additional energy conservation measures in universities.

Based on the above conclusions, the following recommendations serve to determine the main areas of activity for improving the ecological knowledge of higher education students: Effective use of personal capabilities and achievement of optimal technical results; Conducting research on reducing waste and pollution while minimizing raw material and energy use; Understanding the consequences of actions, considering impacts on human health and the environment; Studying the environment and analyzing possible changes; Selecting the most optimal solutions from an ecological perspective; Developing measures to restore and improve the state of the natural environment.

Although this direction involves some of the most important decisions, its outcomes also highlight practical achievements across different actions and regulations. Universities, in particular, benefit from adopting the “green university” concept and from monitoring environmental efficiency indicators at multiple levels. At the same time, further research is needed to confirm these findings and to ensure that the results can be applied more broadly. Such studies would provide more robust evidence to guide policy decisions and the practical implementation of ecologically sustainable practices within universities.

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