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AN EDUCATIONAL FRAMEWORK FOR INTEGRATING NATURE-BASED THINKING INTO SUSTAINABILITY-ORIENTED ENGINEERING EDUCATION

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Abstract: *This paper presents a comprehensive framework for integrating nature-based thinking into engineering education to address urban sustainability challenges. Drawing on surveys and comparative analyses involving students, educators, and community stakeholders, the research identifies significant deficiencies in awareness, practical application, and interdisciplinary integration of nature-based solutions (NBS). Engineering students demonstrate limited exposure to NBS, lacking both conceptual understanding and hands-on experience, while educators struggle to adapt traditional pedagogies to encompass innovative, experiential learning methods. Moreover, community stakeholders emphasize the need for practical approaches that tackle real-world sustainability challenges. The proposed framework advocates curricular reforms that emphasize field projects, collaborative learning, and continuous feedback mechanisms to bridge the gap between theory and practice. By developing critical competencies and inspiring transformative teaching strategies, this approach prepares future engineers to implement sustainable solutions effectively and contribute to resilient urban development.*

Keywords: *Nature-Based Thinking, Engineering Education, Urban Sustainability, Curriculum Reform, Interdisciplinary Learning, Faculty Development, Community Engagement.*

1. INTRODUCTION

Integrating nature-based thinking into engineering education is necessary for developing sustainable skills that address the complex challenges of the modern world. This approach emphasizes the importance of sustainability, interdisciplinary collaboration, and innovative problem-solving in engineering curricula [1,2]. Engineering education is increasingly aligning with global sustainability goals, notably the United Nations Sustainable Development Goals (SDGs), to prepare students for Industry 4.0 [3]. This alignment encourages the development of innovation skills and a sustainability mindset, promoting a holistic, future-oriented approach to engineering practice [1,2]. Innovative educational strategies such as Design-Based Learning (DBL), Problem-Based Learning (PBL), and Practice-Based Education (PBE) provide effective frameworks for integrating sustainability competencies [4,5]. DBL and PBL emphasize systems thinking, multidisciplinary collaboration, and real-world problem-solving—skills essential for NBS design and implementation [6]. PBE further enhances student preparedness by placing learners in authentic professional contexts that integrate work and learning, improving their capacity to navigate complex environmental, socio-political, and technical challenges [7].

Despite this potential, traditional engineering education often focuses heavily on theoretical knowledge and technical procedures, which may not equip students with the adaptability or interdisciplinary perspective required to address sustainability challenges [4]. Emerging models, such as the Aalborg Model, highlight the importance of incorporating non-technical and stakeholder perspectives into curriculum design [5]. Similarly, research-based learning (RBL) methods have shown promise in boosting student engagement, socio-emotional competence, and collaborative problem-solving [8]. This paper proposes a framework to integrate NBS into engineering education,

drawing on extensive survey data from students, educators, and stakeholders. The goal is to identify skill gaps, align educational outcomes with sustainability needs, and promote interdisciplinary, experiential, and community-connected learning.

2. PROBLEM DESCRIPTION

Urban areas face escalating environmental challenges, including climate change, urban heat islands, and disrupted hydrological cycles. Nature-Based Solutions (NBS) offer sustainable, cost-effective approaches to address these issues by leveraging natural processes and ecosystems. However, the integration of NBS into engineering education remains limited, hindering the development of skills necessary for sustainable urban development [8].

The primary problem lies in the lack of awareness and practical training in NBS among engineering students and educators. Current curricula often fail to incorporate interdisciplinary approaches, emerging technologies, and real-world applications of NBS. This gap in education limits the ability of future engineers to design and implement sustainable solutions in urban environments [5,3]. Urban areas are facing multifaceted challenges marked by climate change, environmental degradation, and social inequalities. Engineering education has traditionally focused on technical and theoretical aspects, yet it is urgently in need of integrating sustainable, nature-based approaches into its curricula. Research has revealed significant knowledge gaps in understanding nature-based solutions (NBS) among students, educators, and community stakeholders. The core problem is the mismatch between the current engineering curriculum and the competencies required to design and implement NBS effectively, leading to a lack of practical skills, inadequate exposure to interdisciplinary techniques, and an insufficient foundation for sustainable urban development.

3. APPLICATION FIELD

The application field of this research is engineering education, with a focus on integrating NBS into curricula to address urban sustainability challenges. The study targets undergraduate and graduate engineering programs, particularly in disciplines such as environmental engineering, sustainability, industrial economical engineering, bioengineering, creating synergies among: i) civil and environmental engineering, i.e. design-based disciplines; ii) natural sciences, i.e. disciplines able to assess the effect of NBS on environmental services in urban areas, and evaluate their effect on biodiversity; and iii) social and health science disciplines, i.e. able to understand the role of NBS in human wellbeing and inclusion. The proposed framework is also relevant for professional development programs aimed at practicing engineers and urban planners.

The findings and recommendations from this research can be applied to:

- Curriculum development
- Interdisciplinary collaboration
- Community engagement
- Policy integration

Urban areas face escalating environmental challenges, including climate change, urban heat islands, and disrupted hydrological cycles. This interdisciplinary approach not only adds depth to engineering education but also aligns academic endeavors with real-world demands for sustainable urban transformations.

4. RESEARCH STAGES

The research followed a multi-stage, evidence-based process designed to develop and validate a framework for integrating nature-based thinking into engineering curricula. Each phase was structured to ensure methodological rigor and alignment with both stakeholder needs and pedagogical goals.

A foundational step involved assessing baseline knowledge of Nature-Based Solutions (NBS) among key educational stakeholders: university students, university faculty, pre-university educators, and community actors. This was achieved through structured surveys that captured both quantitative metrics (e.g., familiarity rates, perceived importance) and qualitative insights (e.g., attitudes,

implementation challenges). The objective was not merely to describe awareness levels but to identify asymmetries between recognition and conceptual understanding, which constitute critical barriers to curricular integration.

Building on the awareness assessment, we conducted a comparative analysis of the survey responses to expose consistent patterns of deficiency. The data revealed specific shortcomings—such as insufficient exposure to hands-on NBS applications, a lack of interdisciplinary project experience, and limited faculty familiarity with pedagogical strategies for teaching NBS. These gaps are not incidental but structural, rooted in legacy curriculum models that prioritize disciplinary silos over integrative and experiential learning.

To ensure validity and depth of interpretation, the study employed a mixed-methods approach combining statistical analysis (clustering, inferential testing, principal component analysis) with thematic coding of qualitative responses. This analytical framework enabled us to differentiate stakeholder perspectives and educational priorities with precision. The synthesis of quantitative and qualitative data allowed for the formulation of empirically grounded recommendations tailored to the distinct needs of each group.

5. RESEARCH METHODS

The research methods consisted of mix method approach by combining 4 groups of surveys. From the questionnaires reports we detail this analysis:

- Quantitative analysis

Using descriptive and inferential statistical tools (e.g., chi-square tests, t-tests, clustering analysis) were applied to questionnaire data to quantify awareness levels, skill gaps, and learning preferences.

- Qualitative analysis

Open-ended responses were thematically analyzed to capture the nuanced challenges faced by educators and the practical needs identified by community stakeholders.

- Comparative framework

By comparing results across three stakeholder groups, the study identified convergent and divergent needs, shaping targeted recommendations for curriculum development.

6. RESULTS

The student questionnaire aimed to assess learners' understanding, interest, and educational needs related to nature-based urban solutions. It explored their awareness of environmental challenges, attitudes toward sustainability, and preferred learning methods. The findings will inform curriculum development by identifying key knowledge gaps and aligning content with student interests to better prepare them for addressing real-world sustainability issues.

The questionnaire was distributed at Lucian Blaga University of Sibiu, Czech University of Life Science from Prague, Federico II University of Naples, Italy. Target Population 182, were university students from bachelor studies enrolled in economical engineering, environmental engineering, agricultural engineering fields, ecology and environmental science, urban planning, architecture, and master and doctoral studies students. The sampling method used was stratified random sampling to ensure diversity across academic years, fields of study, and demographics.

The community survey was conducted to assess the needs, challenges, and opportunities for integrating Nature-Based Solutions (NBS) into education and professional training. The survey targeted public officers, urban planners, and community members, with 51 respondents providing insights into their awareness, skills gaps, and preferences for NBS training. The findings of this survey aimed to develop a comprehensive training program to enhance knowledge and implementation of NBS in urban sustainability.

The university teachers pilot research study aimed at understanding the needs, challenges, and opportunities for integrating Nature-Based Solutions (NBS) into university-level education. The research was conducted through a survey of 70 university educators and researchers across various disciplines, including environmental engineering, urban planning, biodiversity, and sustainability.

The survey conducted among preuniversity teachers to assess their current knowledge, skills, and training needs related to Nature-Based Solutions (NBS) and sustainability education had 293 respondents. The goal of the research was to identify gaps and opportunities for integrating NBS into preuniversity curricula, ultimately contributing to a more sustainable future.

6.1 Student awareness and skill gaps

While initial survey data suggest that over 60% of engineering students have encountered the concept of nature-based solutions (NBS), this exposure is largely superficial; only a minority demonstrate practical understanding or the ability to apply NBS in real-world contexts (figure 1).

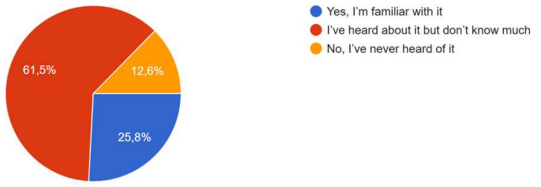

Fig. 1. Responses for "Have you heard of the concept "nature-based solution" for urban area and environmental challenges

This gap does not emerge randomly. It is attributable to the traditional engineering curriculum's predominant focus on theoretical and technical subjects, which leave little room for interdisciplinary or experiential learning pertinent to sustainability (figure 2).

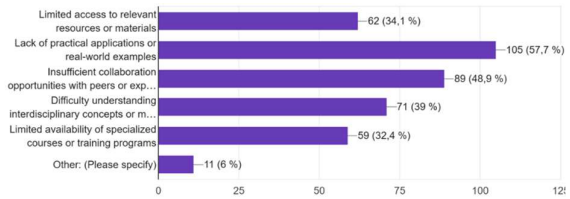

Fig. 2. Responses for "What challenges do you face when studying or working on sustainability-related subjects? (select all that apply)"

The practical implication of this is twofold. First, students lack not just familiarity with the terminology but the ability to analyze, model, and critically evaluate NBS interventions, as indicated by their limited grasp of applications like water purification and urban heat mitigation. Many students recognize NBS as an environmentally friendly alternative within urban planning and sustainability; however, they often exhibit limited grasp over its diverse applications — such as water purification via natural filtration processes or urban heat mitigation through green infrastructure, suggesting that curricular exposure has not fully integrated the multifaceted nature of these solutions.

The gap in awareness extends to the interdisciplinary dimensions of NBS. There is a noticeable deficiency in understanding how concepts from ecology, environmental science, and engineering converge in practical scenarios. This fragmented awareness complicates the ability of students to connect classroom learning with real-world challenges, thereby reducing the potential for innovative, holistic problem-solving in urban environments.

Second, without curricular mechanisms to integrate ecological and socio-economic perspectives, students are unprepared to foresee or manage the cascading effects of design decisions in complex, real-world environments (figure 3).

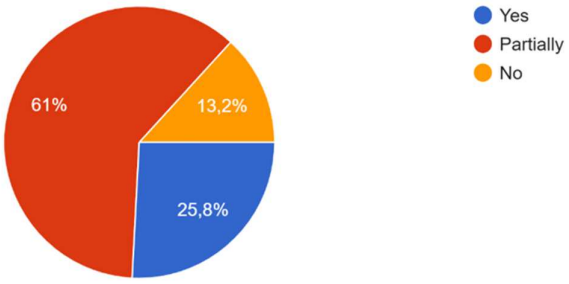

Fig. 3. Responses for "Do you think your current curriculum addresses environmental and urban sustainability challenges effectively?"

This demonstrates the urgent need for curriculum reform that prioritizes not just technical proficiency, but systems-level thinking and hands-on engagement

The surveys also reveal a limited capacity among students to critically assess the broader implications of NBS. This includes an understanding of cost-benefit analyses, lifecycle assessments, and the socio-economic impacts of implementing nature-based interventions. Such critical appraisal is paramount for developing engineering solutions that are not only technically sound but also sustainable and socially equitable. Beyond recognition, skill deficits represent a significant barrier to the effective integration of NBS concepts into engineering curricula.

Students frequently demonstrate insufficient proficiency in technical areas crucial to the design and implementation of NBS. These include the use of digital tools for environmental modeling, simulation software, and data analytics platforms that can effectively evaluate the performance and sustainability of nature-inspired designs. The lack of practical training in these areas jeopardizes the development of a robust skill set necessary for modern engineering challenges.

A core competency in NBS is the ability to employ systems thinking — to discern interdependencies between natural systems and engineered solutions. However, surveys indicate that many students struggle to integrate diverse variables into a cohesive systems analysis. This shortfall hampers their ability to foresee the cascading effects of design decisions and manage the complexities inherent in sustainable urban development.

The modern engineering landscape demands strong collaborative skills, particularly in interdisciplinary settings where multiple perspectives converge to generate innovative solutions. The current curricula often do not stress teamwork in real-world contexts, resulting in limited readiness for interdisciplinary collaboration. This gap is evident in the reluctance or unpreparedness of students to engage in cross-departmental projects that require synthesizing technical, ecological, and societal insights.

6.2 Educator challenges and needs

Educators face substantial challenges in their own knowledge base and pedagogical readiness to teach nature-based solutions (NBS). The data indicates that while 68.6% of educators report some familiarity with NBS concepts, only 14.3% consider themselves very familiar with these approaches, and over 41% lack any direct teaching or research experience in this area.

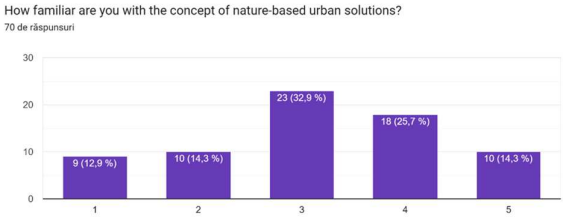

Fig. 4. Responses "How familiar are you with the concept of nature-based solution?"

Effective integration of nature-based thinking into engineering education hinges on sustained faculty development. Without targeted training and institutional support, educators remain ill-prepared to teach the interdisciplinary, systems-oriented content required for sustainability. Many lack practical NBS experience (41.4%) and struggle with outdated teaching methods, disciplinary silos, and inadequate assessment tools for complex competencies like systems thinking.

Survey and qualitative data reveal three main challenges: limited ecological and interdisciplinary knowledge, lack of hands-on NBS experience, and uncertainty about appropriate pedagogical methods. Educators also face systemic barriers, including rigid curricula, lack of standardized resources, and insufficient institutional incentives for innovation.

To address these gaps, educators call for interdisciplinary workshops (with 76.2% expressing interest), collaborative networks, support for innovative teaching practices, and clear frameworks for integrating NBS into existing courses. Institutions must invest in long-term faculty development, recalibrate

reward systems to encourage interdisciplinary teaching, and provide the necessary resources and tools for modern, experiential education.

Supporting educators is essential to meaningful curricular reform. Without this foundation, efforts to embed nature-based solutions in engineering education will fall short of preparing students for real-world sustainability challenges.

6.3 Community insights and practical needs

The integration of nature-based thinking into engineering education necessitates a profound understanding of community perspectives and practical requirements. This section examines the insights gleaned from community stakeholders, including urban planners, public officials, environmental practitioners, and local community representatives, whose experiences and expectations provide crucial context for developing relevant educational frameworks.

Community stakeholders represent the interface between academic theory and real-world implementation of nature-based solutions (NBS). Survey data reveals nuanced perspectives that significantly influence educational priorities.

The pronounced consensus among community stakeholders (88.3%) regarding the importance of NBS in professional practice demonstrates a disconnect between academic preparation and real-world requirements (figure 5,6). Stakeholders identify insufficient technical knowledge (64.7%), challenges in sustainable urban design (58.8%), and regulatory or funding barriers (52.9%) as major obstacles.

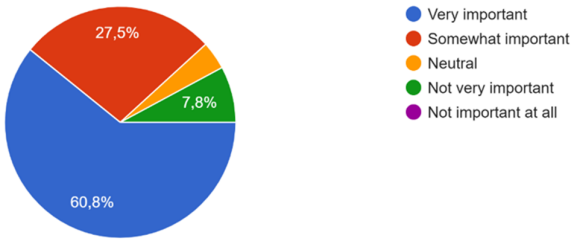

Fig. 5. Importance of NBS for Community Stakeholders

The prioritization of practical skills such as environmental sustainability practices (76.5%) and data analysis (64.7%) further substantiates the need for curricula that transcend theoretical instruction in favor of applied, context-specific problem-solving.

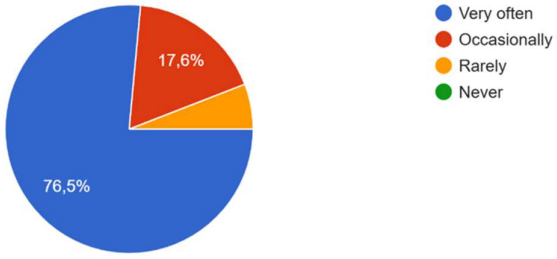

Fig. 6. Responses for "How frequently do you encounter challenges in your current role related to sustainability nature-based solution, and urban environmental issues?"

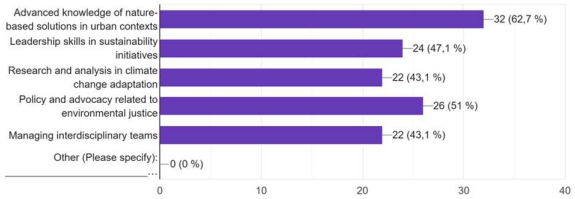

Fig. 7. Responses for "What addition knowledge or skills would you need to take on new roles or advance in your career?"

Community stakeholders emphasize the need for educational approaches that acknowledge both immediate implementation challenges and long-term sustainability considerations. This temporal dimension is often underrepresented in traditional engineering curricula, which tend to focus on discrete problem-solving rather than sustained engagement with evolving systems.

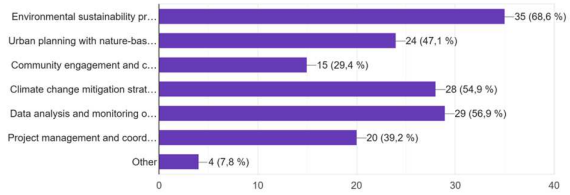

Fig. 8. Responses for "Which skills do you feel that you need to develop or improve to perform your current job more effectively?"

Community stakeholders identify a broad set of skills needed for effective NBS implementation in urban areas. They emphasize technical competencies in sustainability practices (76.5%), data analysis (64.7%), and climate change mitigation (58.8%), alongside ecological literacy, systems modeling, and adaptive management. Equally important are cross-disciplinary skills. Stakeholders value professionals who can communicate technical ideas clearly (70.6%) and collaborate across sectors (64.7%), highlighting the need for education that balances technical, communicative, and collaborative abilities. Adaptability to local contexts is also crucial. Stakeholders stress the importance of tailoring NBS to specific socio-economic, infrastructural, and cultural conditions—demanding both technical and social insight beyond standardized engineering solutions.

Experiential learning is strongly preferred, with field trips (76.5%) and in-person workshops (70.6%) seen as most effective. Most stakeholders are willing to dedicate 2–5 hours per month to training, with some open to more, indicating a need for flexible, practical education models that respect time constraints while delivering real value.

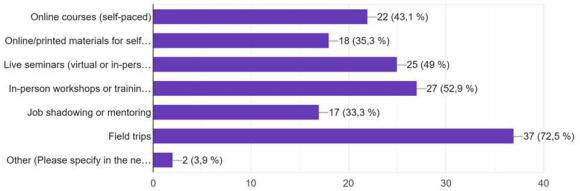

Fig. 9. Responses for "How would you prefer to receive training on nature-based solution?"

Stakeholders are eager for two-way knowledge exchange, where they contribute practical insights while benefiting from academic research. This challenges traditional outreach models and calls for more collaborative, co-creative education.

Their input highlights the need for engineering programs to embed real-world community challenges into the curriculum, helping students engage with the complexities of implementing nature-based solutions (NBS). Structured partnerships with local governments, organizations, and industry should support joint research, service learning, and resource sharing. Community feedback must regularly inform curriculum design to keep it responsive to evolving needs.

Beyond preparing students, institutions should also support practicing engineers through targeted workshops, certification programs, and collaborative learning spaces. By integrating community insights and real-world challenges, engineering education can bridge the theory-practice gap and prepare graduates with the skills and contextual understanding needed for effective NBS implementation in urban environments.

6.4. Comparative analysis

A comparative review of data across the three groups highlights shared recognition of the current curriculum's shortcomings. All stakeholder groups advocate for a stronger emphasis on practical, hands-on experiences that directly address real-world challenges. Additionally, there is significant support for integrating interdisciplinary elements into the curriculum to better align academic theory with industry needs.

6.5 Statistical clustering and differentiated needs

Statistical analyses employing clustering and principal component analysis identified distinct groupings based on NBS awareness and learning preferences.

These groupings underscore the necessity for adaptive curricula that cater to varying levels of prior knowledge and technical skills—thereby fostering enhanced engagement and learning outcomes.

7. FRAMEWORK FOR INTEGRATING NBS IN ENGINEERING EDUCATION

The proposed framework is grounded in empirical findings and enhanced by the

integration of systems thinking (ST), which has demonstrated clear benefits in engineering education. Studies over the past five years show that embedding ST into curricula significantly improves students' analytical capabilities, problem-solving skills, interdisciplinary collaboration, and professional confidence. These improvements are particularly relevant for sustainability-oriented engineering, where complex, multi-variable challenges are the norm.

Table 1

Documented impacts of systems thinking integration on engineering student outcomes

Outcome domain	Documented effect	Typical evidence
Cognitive skills	Higher scores on systems-thinking tests, richer concept-maps and system models	Pre-/post rubric scores; paired-sample tests [9, 10]
Problem-solving quality	More holistic design proposals, improved ability to tackle "wicked" problems	Analysis of capstone reports and design reviews [10, 11]
Interdisciplinary integration	Greater use of economic, environmental and social criteria in designs; better cross-disciplinary communication	Qualitative coding of project artefacts and interviews [9, 12]
Professional dispositions	Higher self-efficacy, systems mindset and motivation to pursue sustainability topics	Reflection journals and survey scales [10]

Based on the study's findings, a structured framework is proposed to integrate nature-based thinking into engineering education. It focuses on competency development, innovative pedagogy, curriculum alignment, institutional backing, and continuous evaluation—each addressing current gaps and enabling sustainable reform. Central to the framework is the development of key competencies such as critical thinking, environmental problem-solving, and systems analysis. Students must also gain practical skills in designing and implementing Nature-Based Solutions (NBS), including the use of digital tools like GIS, remote sensing, and environmental modeling. Interdisciplinary collaboration is emphasized to equip students for cross-sector work in engineering, planning, and environmental science. Pedagogical approaches should shift from lecture-based formats to experiential learning, including fieldwork, lab experiments, community projects, and case studies. Teaching strategies must accommodate diverse learning needs through blended and interactive methods that offer both foundational and advanced material. Curriculum development should include interdisciplinary electives on NBS, sustainability policy, and ecological engineering, supported by partnerships with governments and environmental organizations. These collaborations provide practical experience through internships and projects, ensuring academic content remains relevant. Curricula must be regularly updated based on new research and stakeholder feedback.

8. CONCLUSION

Integrating nature-based solutions (NBS) into engineering education is an evidence-driven imperative. While many students and educators are familiar with the term, their understanding often lacks depth, and practical experience is limited. Community stakeholders, who are essential to the real-world application of these concepts, recognize the importance of NBS but continue to face barriers related to technical knowledge and implementation.

This disconnect reveals a fundamental misalignment between current engineering curricula and the applied, interdisciplinary demands of sustainable urban development. To address this, engineering programs must prioritize the inclusion of NBS content through interdisciplinary modules that combine theory, data analysis, and hands-on, team-based

projects. Educator development must extend beyond content delivery to embrace innovative teaching practices such as problem-based learning and digital modeling, supported by peer networks that break down disciplinary silos.

Equally important is the sustained collaboration with community stakeholders through joint projects, internships, and feedback mechanisms. Such engagement ensures curriculum relevance and helps overcome challenges related to regulation and local context. Adaptive, performance-based assessments linked to real-world competencies are essential to track educational impact and meet evolving community needs.

The strategic integration of experiential, interdisciplinary, and stakeholder-driven learning is key to equipping future engineers with the skills needed for NBS implementation. This transformation not only supports global sustainability goals but also reinforces the engineering profession's relevance in an increasingly complex, urbanized world. Continued research should focus on tracking long-term outcomes and refining educational strategies to keep pace with both global imperatives and local realities.

9. REFERENCES

[1] Ortega-Sánchez, M., Moñino, A., Bergillos, R., Rivera, M., Hermosilla, P., Delgadillo, J., Echeverría, D. *The Sustainable Development Goals (SDGs) as a Basis for Innovation Skills for Engineers in the Industry 4.0 Context*, Sustainability, 12, 6622, 2020, https://doi.org/10.3390/su12166622.

[2] Namasivayam, S., Al-Obaidi, A., Fouladi, M. *A Conceptual Curriculum Design Approach for Educating Engineers of and for the Future,* Indonesian Journal of Science and Technology, 2023, https://doi.org/10.17509/ijost.v8i3.59580.

[3] Barna, O., Csete, S. *Integrating sustainable competences and green skills in the Hungarian environmental engineering education. The European Society For Engineering Education (SEFI) - SEFI 2022,* 2022, https://doi.org/10.5821/conference-9788412322262.1430.

[4] Huang, Z., Peng, A., Yang, T., Deng, S., He, Y. *A Design-Based Learning Approach for Fostering Sustainability Competency in Engineering Education*, Sustainability, 2020, https://doi.org/10.3390/su12072958.

[5] Lehmann, M., Christensen, P., Du, X., Thrane, M., *Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education,* European Journal of Engineering Education, 33, 283 – 295, 2008, https://doi.org/10.1080/03043790802088566

[6] Chan, M., Nagatomo, D. *Study of STEM for Sustainability in Design Education: Framework for Student Learning and Outcomes with Design for a Disaster Project,* Sustainability, 2021, https://doi.org/10.3390/su14010312.

[7] Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., Crossin, E., Cosson, B., Turner, J., Mazzurco, A., Dohaney, J., O'Hanlon, T., Pickering, J., Walker, S., Maclean, F., & Smith, T. *From problem-based learning to practice-based education: a framework for shaping future engineers.* European Journal of Engineering Education, 46, 27 – 47, 2020, https://doi.org/10.1080/03043797.2019.1708867.

[8] Dhinakaran, V., Partheeban, P., Raguraman, D., Shree, M., Sai, M. *Powering Sustainable Development Through the Integration of Teaching and Research in Engineering Education.* 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), 1400-1402, 2020, https://doi.org/10.1109/ICACCS48705.2020.9074449.

[9] Peretz, R., Tal, M., Akiri, E. et al. *Fostering engineering and science students' and teachers' systems thinking and conceptual modeling skills*. Instr Sci 51, 509–543 (2023). https://doi.org/10.1007/s11251-023-09625-9

[10] Azad, A., Moore, E., L*essons learned from teaching system thinking to engineering students*. 2023: Proceedings of the Canadian

Engineering Education Association (CEEA-ACEG) Conference June 17-21 Kelowna, BC, Proceedings of the Canadian Engineering Education Association (CEEA), 2024, https://doi.org/10.24908/pceea.2023.17007

[11] Azad, A., & Moore, E., & Hounsell, A., *Advancing Engineering Education: Linking Systems Thinking Skills to the Tools through a Revised Framework* Paper presented at 2024 ASEE Annual Conference & Exposition, Portland, Oregon, June 2024 DOI 10.18260/1-2—46525, https://peer.asee.org/46525

[12] Tamir, R., Maman, S., *System-thinking progress in engineering programs: A case for broadening the roles of students.* Frontiers in Education, 8, 1138503, 2023, https://doi.org/10.3389/feduc.2023.1138503

Un cadru educațional pentru integrarea gândirii bazate pe natură în formarea inginerească orientată spre durabilitate

Această lucrare prezintă un cadru cuprinzător pentru integrarea gândirii bazate pe natură în educația inginerească, în vederea abordării provocărilor legate de durabilitatea urbană. Pe baza sondajelor și a analizelor comparative realizate în rândul studenților, cadrelor didactice și al părților interesate din comunitate, cercetarea evidențiază deficiențe semnificative în conștientizarea, aplicarea practică și integrarea interdisciplinară a soluțiilor bazate pe natură (NBS). Studenții la inginerie au o expunere limitată la NBS, lipsindu-le atât înțelegerea conceptuală, cât și experiența practică, în timp ce profesorii întâmpină dificultăți în adaptarea pedagogiilor tradiționale la metode inovatoare și experiențiale de învățare. În plus, părțile interesate din comunitate subliniază necesitatea unor abordări practice care să răspundă provocărilor reale de durabilitate. Cadrul propus susține reforme curriculare care pun accent pe proiecte de teren, învățare colaborativă și mecanisme de feedback continuu, pentru a reduce decalajul dintre teorie și practică. Prin dezvoltarea de competențe esențiale și încurajarea unor strategii de predare transformative, această abordare pregătește viitorii ingineri să implementeze soluții sustenabile în mod eficient și să contribuie la dezvoltarea urbană rezilientă.

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