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HOUSING DECARBONISATION SKILLS FOR CLIMATE, HEALTH AND JOBS

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Abstract. Integrating digital skills into civil engineering education can significantly enhance student engagement and increase the field's appeal by aligning it with modern technologies and evolving industry demands. Three higher education institutions from the Baltic region have partnered to advance housing decarbonisation skills aimed at reducing CO_2 emissions and improving housing health. Complementing their expertise, two SMEs from the digital and energy efficiency sectors and a Centre of Excellence specialising in zero-energy and resource-efficient housing have joined to form the Skills4Deca project team under the Digital Europe Programme. The Skills4Deca initiative involves the design and delivery of approximately 50 standalone courses at various levels – Microlearning, Bachelor, and Master – integrated into existing accredited programmes. The courses will feature advanced learning tools, including Adaptive Massive Open Online Courses, Computer Learning Systems, Adaptive Video and Text Systems, Web Text Mining, Access to E-Sources, Virtual and Real-Time Labs, Virtual AI Learning Environments, and 5D, 6D, and 7D Simulation Packages for Digital Twins. Additional content will address Sensors and Measurement Devices as well as Educational Games within the Moodle Virtual Learning Environment. Graduates of these programmes will be equipped to apply digital solutions across diverse domains of housing management, including materials, structural systems, photonics solutions, energy consumption and auditing, financial planning, decarbonisation strategies, well-being enhancement, and future housing management.

1 INTRODUCTION

Population growth, increasing demand for new infrastructure, and the deterioration of existing structures – combined with challenges such as transportation congestion, water and energy shortages, sustainable development, pollution, and heightened exposure to natural hazards – underscore the urgent need for a new generation of civil engineers [1]. However, in recent years, the number of students pursuing engineering degrees in European countries has declined. Contributing factors include the demanding nature of the curriculum, the attractiveness of alternative pathways to well-paying technical careers, and concerns about the long-term career prospects of engineering graduates [2]. Integrating digital skills into civil engineering education can significantly enhance student engagement and increase the field's appeal by aligning it with modern technologies and industry requirements. Consequently,

digitalisation has become essential for higher education institutions seeking to attract a broader and more diverse student body, while simultaneously improving the quality of courses, instructional materials, and training programmes [3,4].

Generation Z, generally defined as those born between 1997 and 2012, grew up in an environment saturated with smartphones, high-speed internet, and social media. This exposure has made them highly adept with technology and skilled at multitasking across various digital platforms [5,6]. However, Gen Z faces several educational challenges, one of which is the growing concern that traditional schooling fails to adequately prepare students for the future workforce and the demands of an increasingly digital economy. This is linked to the fact that traditional education systems often struggle to keep up with the rapidly evolving world. When considering improvements to educational tools, it's important to note that Gen Z prefers engaging with digital platforms and tools to enhance their learning experience [7] and places a greater value on practical, real-world skills rather than just academic knowledge [8].

Today, one of the most pressing and compelling challenges in civil engineering, which intersects with various scientific technologies and can be particularly relevant to Gen Z, is the impact of decarbonization [9,10,11]. This process focuses on reducing or eliminating carbon emissions throughout the entire lifecycle of infrastructure—from construction and operation to demolition. As industries worldwide strive to lower their environmental footprint, the urgency of decarbonization in civil engineering continues to grow, positioning it as a crucial element in the global effort to combat climate change.

Three higher education institutions from the Baltic countries have come together to address a shared goal: developing skills in housing decarbonization to reduce CO2 emissions and enhance housing quality. In addition, two SMEs from the digital industry and energy efficiency sectors, alongside a Centre of Excellence focused on zero-energy and resource-efficient housing, have formed a collaborative team for the Skills4Deca project under the Digital Europe Programme. As part of this initiative, the participating institutions will design and deliver approximately 50 standalone courses across various levels (Microlearning, Bachelor, and Master), integrating them into existing accredited programs.

The article outlines the project ideas and digital tools that will be incorporated into the microcourses, including: Adaptive Massive Open Online Courses (MOOCs), Computer Learning Systems, Adaptive Video and Text Systems, Web Text Mining, Access to E-Sources, Virtual Labs, Real-Time Virtual Labs, Virtual AI Learning Environments, 5D, 6D, and 7D Simulation Packages for Digital Twins, Learning Content on Sensors and Measurement Devices, and Educational Games within the Moodle Virtual Learning Environment.

2 DISCUSSION

The Skills4Deca project, which began in 2024, is led by a consortium of partners, including universities from the Baltic region (Riga Technical University, Vilnius Gediminas Technical University, Tallinn University of Technology, Institute of Solid State Physics of University of Latvia) and two SMEs specializing in digital innovation and energy efficiency. In the region spanning three countries, it has been recognized that many students and educators in civil engineering face challenges in effectively using digital tools, limiting the full potential of online learning. Another major concern is that, in combination with unfavorable demographic factors and civil engineering's declining appeal, a large number of students drop out after the first

semester, citing a mismatch between their expectations and the chosen field of study. It appears that the issue arises when Gen Z students are placed in traditional learning environments of civil engineering subjects without sufficient integration of digital technologies. As previously noted, Generation Z is deeply familiar with digital technologies and highly comfortable using interactive online tools. Without adequate integration of digital resources, students may struggle to engage fully with the material, leading to reduced motivation, lower retention of information, and an overall less effective learning experience. Often, this can be a reason why students choose to discontinue their studies. Additionally, it's important to note that a lack of digitalization can impede the development of essential skills required in today's technology-driven workforce. As such, embedding digital tools and resources into the educational process is key to engaging today's tech-savvy learners.

In response to these challenges, the Skills4Deca project—driven by a strong focus on energy efficiency, digital transformation, and the EU Green Deal—aims to bridge the digital skills gap among housing managers, construction engineers, energy auditors, and designers, including those with little or no prior digital expertise. Graduates will gain the digital, technological, legal, and financial skills necessary to design and implement solutions that reduce energy consumption in millions of existing homes across Europe. Additionally, they will be equipped to apply the latest technological advancements and legal innovations in the design of future buildings. It seems to be attractive not only to Gen Z students but also to specialists in practice who want to improve their skills.

As planned, innovative pedagogical content will be integrated into existing undergraduate and graduate programs as a strategic update, enhancing the relevance and impact of education in the building decarbonisation sector. Figure 1 below illustrates the anticipated improvements and the interconnections between the various activity blocks in Skills4Deca.

VILNIUS TECH plan to integrate the developed Skills4Deca e-micro courses (worth 1 ECTS) into existing 6 ECTS courses, with the goal of future expansion in course digitalization. As Gen Z is visually oriented, has a shorter attention span, and absorbs information in shorter bursts, micro-courses can be an effective tool for helping these students grasp the content of the entire course [12,13]. This approach offers targeted, efficient learning experiences while ensuring that comprehensive and in-depth content is still conveyed through the main modules.

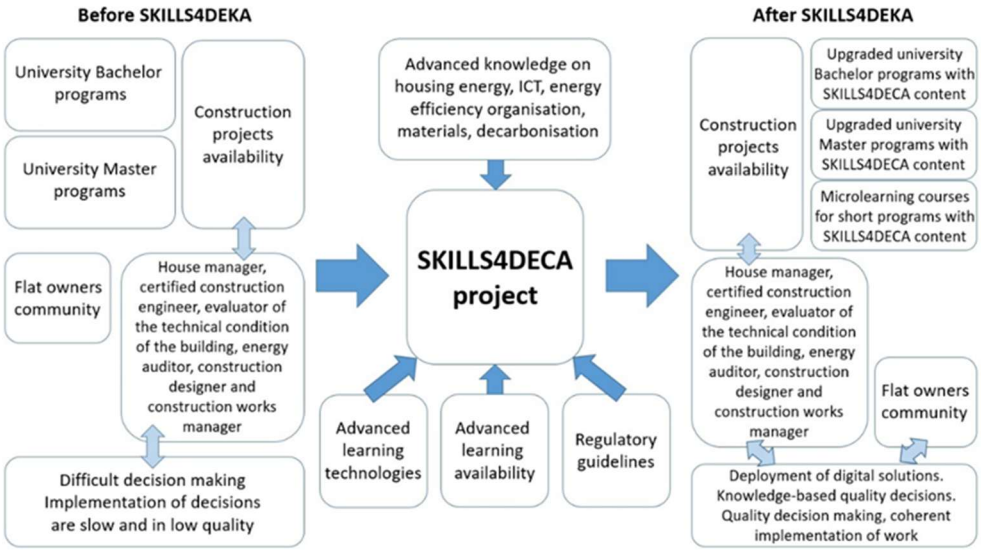

Figure 1: Block diagram of Skills4Deca activities

VILNIUS TECH will bring to Skills4Deca its expertise in Civil & Structural Engineering, Construction and Real Estate Management, developing 18 micro courses (Fig. 2). Among the microcourses being developed are: A human-centred cognitive buildings, Blockchain and the built environment, Green and friendly house building materials based on waste, Application of circular economy principles in structural design, Modern sustainable buildings and their structures of steel, wood and composites, and many others. Digital tools that will be incorporated into the micro courses, including: Adaptive MOOCs, Computer Learning Systems, Virtual AI Learning Environments, and advanced 5D–7D Simulation Packages for Digital Twins, Learning Content on Sensors and Measurement Devices, and Educational Games within the Moodle Virtual Learning Environment. Graduates will apply digital solutions in various housing management domains, including: materials, structures, photonics solutions, energy consumption and auditing, financial planning, decarbonisation, well-being, management for future housing – fostering both educational innovation and multi-stakeholder impact.

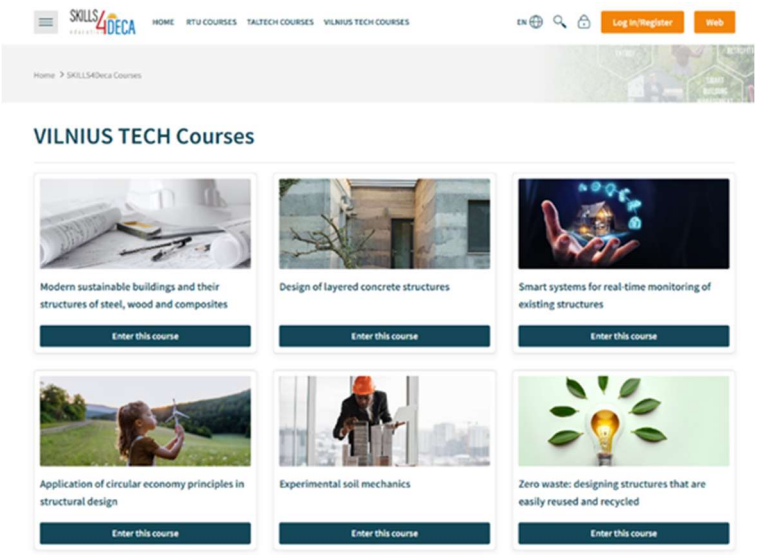

Figure 2: VILNIUS TECH micro-courses on the Skills4Deca platform

The structure of the micro-course in Moodle Virtual Learning Environment consists of key information about the teachers, course content with brief textual explanations, adaptive tests for students, knowledge assessments, tasks for students, and a final online examination. Tasks involve students reading program-generated texts related to specific content, watching generated videos, taking 3D virtual tours of different laboratories with recognized test methodologies, working with e-calculators, analyzing e-data sets, playing games and more. In this manner, the micro-course is fully interactive, eliminating the need for face-to-face teacher-student learning. In developing digital tools and content, the results of several educational research studies were taken into account and applied.

1. Adaptive testing and examination questions were adapted to be gender-inclusive. This approach was based on several studies that highlight differences in civil engineering education between women and men [14, 15,16]. For this purpose, different styles of examination questions were used in academic assessments, based on research indicating that female students tend to outperform male students in both multiple-choice and constructed-response formats. However, their advantage is more pronounced in constructed-response questions, suggesting that multiple-choice formats may slightly favor male students [17].

2**. For text or video** generation, emotion recognition techniques were used to evaluate student emotional states and predict their behavior [18], ensuring the delivery of the most suitable (according level) educational material. Russel's circumplex model of emotions (Fig. 3) which provides a distribution of basic emotions in two-dimensional space in respect of valence and arousal was used in developed software. It tailors the learning content (different level of information) to each student, taking into account factors such as the level of interest, difficulty of the studies, and stress levels, with the help of biometric technologies [19].

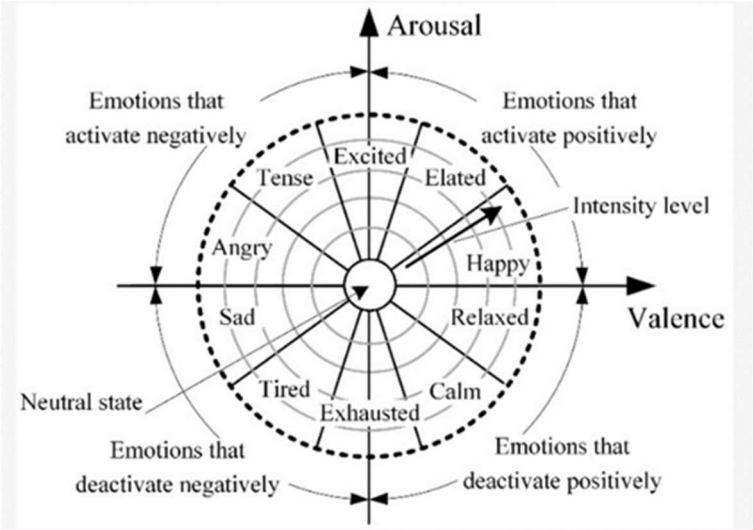

Figure 3: Russel's circumplex model of emotions

3. Virtual laboratories are increasingly recognized as valuable tools in engineering education, including civil engineering. They offer several advantages over traditional physical labs, such as cost-effectiveness, accessibility, and enhanced safety [20,21,22]. At least three virtual laboratories are being developed to help students familiarize themselves with the latest laboratory equipment available at Vilnius Tech. Each virtual lab will include detailed equipment descriptions, methodologies, existing lab work instructions, videos, databases, and other relevant components. 3D virtual tours of the following laboratories will be available on the learning platform: Soil Mechanics and Additive Manufacturing Laboratory (Fig.4), Building Materials Testing Laboratory, Applied Laboratory of Buildings, Constructions and Materials.

Figure 4: Soil Mechanics and Additive Manufacturing Virtual Laboratory

3 CONCLUSIONS

- The integration of digital skills into civil engineering education presents a powerful opportunity to enhance student engagement while aligning curricula with modern technological advancements and industry demands. A particularly urgent challenge for today's learners – especially Generation Z – is understanding the impact of decarbonization on the built environment. In response, the Skills4Deca project, funded under the Digital Europe Programme, addresses this need by focusing on energy efficiency, the EU Green Deal, and bridging the digital skills gap among key professional roles – even among those with limited digital backgrounds. The development of interactive e-microcourses – embedded within existing 6 ECTS modules – provides a scalable, flexible model of digitally enabled learning that reduces dependency on face-to-face instruction. Planned expansions in digital content further aim to increase accessibility, equity, and engagement across diverse learner populations.
- Crucially, the design and implementation of Skills4Deca draw on pedagogically sound innovations such as gender-inclusive adaptive testing, emotion recognition for learner feedback, and the integration of virtual laboratories. Each virtual lab includes comprehensive resources to simulate hands-on experience, providing students with practical exposure to advanced tools and methodologies.
- Beyond its immediate application in civil engineering, the Skills4Deca framework offers a transferable model for digital curriculum transformation across STEM and sustainability-focused disciplines. Its modular structure, low-barrier digital tools, and inclusive pedagogical design make it adaptable for a wide range of educational contexts and sectors seeking to future-proof their learning environments. As such, Skills4Deca not only addresses current educational and environmental imperatives but also serves as a replicable blueprint for equipping future professionals with the skills needed in an increasingly digital and decarbonized world.

REFERENCES

[1] M. Nehdi, *"Crisis of civil engineering education in information technology age: analysis and prospects,"* 31st Annual Frontiers in Education Conference. Impact on Engineering and Science Education. Conference Proceedings (Cat. No.01CH37193), Reno, NV, USA, 2001, pp. T2B-20, https://doi.org/10.1109/FIE.2001.963874.

[2] https://www.worldexpertise.com/Declining_Interest_in_Engineering_Studies_at_a_Time_of_Increased_Business_Needs.htm

[3] Gurung, B.; Rutledge, *D. Digital learners and the overlapping of their personal and educational digital engagement.* Comput. Educ. 2014, 77, 91–100. https://doi.org/10.1016/j.compedu.2014.04.012

[4] Alenezi, M. *Deep dive into digital transformation in higher education institutions.* Educ. Sci. 2021, 11, 770. https://doi.org/10.3390/educsci11120770

[5] Anca, C. D., Alexandra, C. M., & Adrian, S. (2020, October). *Teaching Z generation engineers. Using entrepreneurship education to develop soft skills and match employers'*

expectations. In 2020 International Conference and Exposition on Electrical And Power Engineering (EPE) (pp. 180-184). IEEE. https://doi.org/10.1109/EPE50722.2020.9305662

[6] Dhinakaran, V., Partheeban, P., Ramesh, R., Balamurali, R., & Dhanagopal, R. (2020, March). *Behavior and characteristic changes of generation z engineering students.* In 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS) (pp. 1434-1437). IEEE. https://doi.org/10.1109/ICACCS48705.2020.9074322

[7] Ramírez-Donoso, L., Pérez-Sanagustín, M., Neyem, A., Alario-Hoyos, C., Hilliger, I., & Rojos, F. (2023). *Fostering the use of online learning resources: results of using a mobile collaboration tool based on gamification in a blended course.* Interactive Learning Environments, 31(3), 1564-1578. https://doi.org/10.1080/10494820.2020.1855202

[8] Escobar-Bazaldua, A., Rodríguez-Dobarganes, P., & Flores-Martínez, M. (2024, May). *The Influence of an Industry Partner on the Development of Manufacturing-Processes Competencies in Generation Z Engineering Students.* In 2024 IEEE Global Engineering Education Conference (EDUCON) (pp. 1-8). IEEE. https://doi.org/10.1109/EDUCON60312.2024.10578823

[9] Wallace, B. (2024). *The Great Civil Engineering Overhaul*. Pages 1 – 394. https://doi.org/10.1061/9780784485446

[10] McCord, K. H., Dillon, H. E., Gunderson, P., Carlson, S., Phillips, A. R., Griechen, D., & Antonopoulos, C. A. (2024). *Strategies for connecting whole-building LCA to the low-carbon design process.* Environmental Research: Infrastructure and Sustainability, 4(1), 015002. https://www.doi.org/10.1088/2634-4505/ad17ce

[11] Dong, C., Cao, L., Gao, W., Tian, X., & Liu, B. (2023, October). *Digital Innovation of Engineering Cost in the Context of Low Carbon Economy.* In 2023 International Conference on Information Processing and Network Provisioning (ICIPNP) (pp. 142-145). IEEE. https://doi.ieeecomputersociety.org/10.1109/ICIPNP62754.2023.00037

[12] Shail, M. S. (2019). *Using micro-learning on mobile applications to increase knowledge retention and work performance: a review of literature*. Cureus, 11(8). https://doi.org/10.7759/cureus.5307

[13] GOTTIPATI, S., & SHANKARARAMAN, V. (2017). *Analyzing the e-learning video environment requirements of generation Z students using echo360 platform* Analyzing the e-learning video environment requirements of Generation Z students using Echo360 platform

[14] Tsakalerou, M., Perveen, A., Ayapbergenov, A., Dikhanbayeva, D., & Lukhmanov, Y. (2025). *Rethinking Gender Inclusion in Course Curricula: Opening Pandora's Box in STEM Education.* IEEE Transactions on Education. https://doi.org/10.1109/TE.2025.3558122

[15] Chen, J., Kolmos, A., & Clausen, N. R. (2023). *Gender differences in engineering students' understanding of professional competences and career development in the transition from education to work.* International Journal of Technology and Design Education, 33(3), 1121-1142. https://doi.org/10.1007/s10798-022-09759-w

[16] Vasconcelos, R. M., & Almeida, L. S. (2018, October). *Learning and academic success in engineering courses: Comparing 1st year students according to gender.* In 2018 IEEE Frontiers in Education Conference (FIE) (pp. 1-4). IEEE. https://doi.org/10.1109/FIE.2018.8658805

[17] Arthur, N., & Everaert, P. (2012). *Gender and performance in accounting examinations:*

Exploring the impact of examination format. Accounting Education, 21(5), 471-487. https://awspntest.apa.org/doi/10.1080/09639284.2011.650447

[18] Dzedzickis, A., Kaklauskas, A., & Bucinskas, V. (2020). *Human emotion recognition: Review of sensors and methods.* Sensors, 20(3), 592. https://doi.org/10.3390/s20030592

[19] Kaklauskas, A., Zavadskas, E. K., Pruskus, V., Vlasenko, A., Seniut, M., Kaklauskas, G., ... & Gribniak, V. (2010). *Biometric and intelligent self-assessment of student progress system.* Computers & Education, 55(2), 821-833. https://psycnet.apa.org/doi/10.1016/j.compedu.2010.03.014

[20] Heradio, R., De La Torre, L., Galan, D., Cabrerizo, F. J., Herrera-Viedma, E., & Dormido, S. (2016). *Virtual and remote labs in education: A bibliometric analysis.* Computers & Education, 98, 14-38. https://doi.org/10.1016/j.compedu.2016.03.010

[21] Panasiuk, O., Akimova, L., Kuznietsova, O., & Panasiuk, I. (2021, September). *Virtual laboratories for engineering education.* In 2021 11th International Conference on Advanced Computer Information Technologies (ACIT) (pp. 637-641). IEEE. https://doi.org/10.1109/ACIT52158.2021.9548567

[22] Coutinho, G. S., Magana, A. J., & do Rego Dias, V. (2023, June). A *Framework for the Development of Online Virtual Labs for Engineering Education*. In 2023 ASEE Annual Conference & Exposition. https://doi.org/10.18260/1-2--42396