Implementation of open educational resources in the context of the student-centred approach

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Abstract. The article outlines pedagogical technologies for teaching environmental engineering in online learning systems of higher education using open educational resources (OER) with a student-centred approach. A technology integrating OER, including educational videos, online explanations for practical work, modular testing, and e-textbooks, was experimentally tested. The proposed technology was evaluated using a control and experimental group design at two universities. Statistical analysis using Pearson's chi-squared test showed a significant improvement in learning outcomes for the experimental group exposed to OER ($\chi^2 = 45.55, p < 0.01$). The results demonstrate that a student-centred approach leveraging OER is a promising method to enhance the learning of complex subjects like environmental engineering. This study addresses a gap in empirical research on discipline-specific applications of OER. The findings are discussed in the context of recent literature highlighting the benefits of OER for accessibility, engagement, and learning outcomes in higher education. Recommendations are provided for the effective integration of OER by instructors and institutions.

Keywords: professional training · environment engineering · online learning environment · open educational resources

1   Introduction

A high level of adaptability and interaction with students characterizes modern educational environments. This is realized through reviewing the concept of building educational materials and processes from the standpoint of a student-centred approach. Information technologies are developing rapidly and require innovative approaches to the management of the educational process. There is a need to provide students with learning tools that are engaging and not limited to digitized materials. It is necessary to make full use of modern technologies for creating and delivering knowledge to students, to provide different methods, completeness and pace of providing educational material within open educational resources (OER) that will be convenient for the student [6, 14, 22].

A feature of modern education is an educational space with accessible scientific and educational content combined with traditional information sources. Modern universities are on the path of global digitalization; it is necessary to have appropriate skills in using modern digital platforms and achieve knowledge in open online courses [1, 23]. Thus, the educational process is transformed into an electronic environment using the content of OER. The problem is choosing and implementing specific content that considers the peculiarities of the disciplines presented in the curriculum.

The article aims to experimentally test the peculiarities of implementing OER in the context of a student-centred approach.

2   Literature review

OER are teaching, learning, and research materials in any medium that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation, and redistribution by others with no or limited restrictions [14]. OER include complete courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge [6]. The use of OER is increasingly seen as a way to provide learners with high-quality educational materials at low or no cost, to promote innovative teaching practices, and to foster equitable access to education [1, 16].

Despite growing awareness and interest, the adoption of OER in higher education remains relatively low globally [14]. This is due to several challenges, including discoverability of relevant OER, uncertainty about quality and trustworthiness, lack of institutional support, and the need for digital literacy skills among faculty and students [4, 15]. Additionally, there is a lack of research on the effectiveness of OER in specific disciplines and contexts [21, 29].

In engineering education, OER has the potential to address key challenges such as the high cost of textbooks, the need for up-to-date and industry-relevant content, and the importance of hands-on, project-based learning [20, 27]. However, there are few studies on the implementation and impact of OER in this

domain. Prior work has examined the general educational environment and information technologies in engineering education [5, 19, 26], but not the specific role of OER.

Realizing the benefits of OER requires not just providing access but integrating them into a student-centred pedagogical approach [10]. This means using OER to support active learning, personalized instruction, self-directed exploration, and authentic assessment [18]. It also requires providing faculty with training and support to effectively curate, adapt, and implement OER [11, 13].

Student engagement and outcomes are key measures of the success of OER initiatives. Several studies have found that OER adoption is associated with improved grades, course completion rates, and student satisfaction [9, 25]. However, the impact may vary depending on factors such as the quality of the OER, the level of integration into the curriculum, and student characteristics [28].

Long-term sustainability is another important consideration for OER initiatives. This requires ongoing investment in the maintenance and updating of resources, as well as strategies for collaboration and sharing within and across institutions [2, 24]. Policies and incentives for open educational practices, quality assurance mechanisms, and infrastructure for storage and dissemination are all critical components [3, 17].

3   Methods

An experimental study was conducted with undergraduate students in environmental engineering programs at Mykolayiv National Agrarian University and the Academy of Labour, Social Relations and Tourism during the 2023-2024 academic year. The control group ($n = 182$) learned using traditional online lectures, while the experimental group ($n = 181$) supplemented lectures with OER selected to enable student-centred learning.

The specific OER used in the experimental condition included:

– educational videos demonstrating key concepts and real-world applications;
– online guides and worked examples for practical assignments and projects;
– modular self-assessments with instant feedback for gauging understanding;
– open e-textbooks and readings to provide an in-depth exploration of topics.

The instructors curated these OERs to align with course learning outcomes and integrated them into the learning management system. Students were trained on accessing and using the resources.

Learning outcomes were measured by comparing the distribution of grades between groups on the end-of-course exam. Pearson's chi-squared test was used to evaluate the significance of observed differences [7]. Additionally, student perceptions of OER were collected through surveys and interviews.

4   Conceptual framework

Currently, the system of higher education in the world is experiencing an era of significant innovations and changes in fundamental principles. Today's target

orientations of the information society envisage the weakening of the university's institutional positions. Losing the features of hierarchy, linearity, centralization, and the system of vertical connections, the system of higher education turns into an open informational, educational network consisting of open educational resources. The main features of an open educational resource are:

- globalization and openness – the informational educational web-space has a global character, space-time, age boundaries are practically absent, access to information and educational resources is free in most cases;
- individualization and desynchronization – the opportunity to choose an individual training program, listen to courses in different educational institutions, independently determine the terms of training, and, as a result, build an individual trajectory of professional development;
- diversity – methods, forms, methods of obtaining education vary depending on the individual preferences of students; however, the diploma obtained must meet global standards; the participants in the educational process are diverse both from the side of educational service providers and from the side of users;
- minimization and decentralization – orientation of the educational process to study in small groups or individually, over time the need for huge university buildings and classrooms will disappear, the presence of a system of horizontal connections arising from interaction at the level of educational institutions in different cities and countries, decentralization of management educational institutions;
- the polylogical character of the tutor-student interaction, where the roles of the student and tutor are transformed into a partnership relationship, the educational process has the character of subject interaction, mutual learning and development.

The implementation of an open educational resource is already forming, and modern universities will be forced to join it as full participants. Distinctive features of an open educational resource:

- methodical, educational or scientific orientation of materials;
- support of various formats and media for submitting materials for the purpose of acquiring professional competencies;
- ensuring free access, use, processing and redistribution of materials by other users.

An open educational resource can be a complete electronic training course or educational module, as well as individual elements or their combinations: methodical materials, learning tools, workshops, video and audio materials, tests, control tasks, software, or other materials, tools, or technologies aimed at ensuring (supporting) access to knowledge. Open access tools and information and communication technologies allow the implementation of electronic educational resources both in the form of ready-made electronic training courses and offline tutorials that meet the needs of modern students.

The open educational resource is an electronic course that contains interactive content, audiovisual materials, tests and other communication tools aimed at mastering content from the relevant disciplines.

Open educational resources are developed by taking modern software platforms into account. Today, in global practice, a remote approach to the training of specialists is widely used. In the context of distance learning in the conditions of an open educational resource, the universities face the following tasks:

– improvement and further development of the student-centred model of the organization of the educational process;
– creation of high-quality programs for open educational resources, which would form the relevant competencies needed by specialists in the industry, who are in demand in the labour market;
– accumulation within the higher education institution of existing knowledge in priority areas, organization of scientific work for further improvement of knowledge and its translation with the use of practitioners of relevant types of activities;
– construction of a flexible student training schedule, improvement of the motivation system, construction of a system of public accreditation of higher education institutions;
– improving the methods of organizing the educational process in accordance with the active use of achievements in the field of ICT, as well as based on the experience of advanced universities.

According to modern trends in the development of the educational process, the emphasis is primarily on the higher education applicants. A schematic display of connections is presented in figure 1.

According to the proposed model, the entire educational process should focus on the student, who is located in the centre. As a result, all the university's resources should be directed to meeting the needs of the higher education applicant to study, increasing his potential, and motivating him for further studies.

Following this model makes it quite challenging to follow the stream-group model of building the educational process, which consists of admitting higher education applicants to the university and then distributing the entire stream into a certain number of groups. Students undergo training throughout the regulatory term in the composition of these groups.

The possibilities of organizing the educational process using information and communication technologies to meet the demands of the student make it possible to highlight several methods that can be its basis. Although many of these methods already exist, not all methods can be found in the practice of universities.

The first method consists of organizing a student-oriented learning trajectory based on the active involvement of employers interested in qualified specialists. According to the latest discussions on the organization of the educational process, all higher education institutions are obliged to interact with representatives of enterprises in the relevant activities.
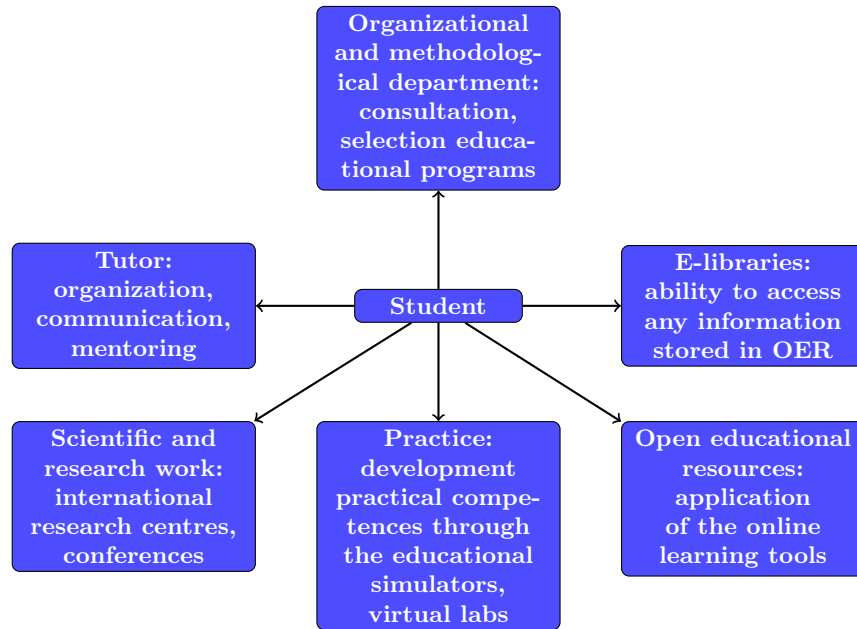
Fig. 1. Student-centred approach in implementation open educational resources.

According to this model, students will be interested in learning while simultaneously gaining practical experience by participating in various practical projects since the specificity of the requirements of large companies in the market is the need to have at least some practical work experience in the chosen direction.

In order to ensure the technologicalization of the work process of implementation of open educational resources, the following tools provided by the virtual environment are required:

- tools for discussion and evaluation of materials by users of the virtual environment for the operational management of the process of implementation of open educational resources at all stages;
- tools for analysis, visualization and processing of information;
- an integrated system of rating evaluation of materials, which plays the role of one of the built-in tools for data analysis and processing;
- toolkit for decision-making regarding the further use of material for educational and scientific activities. Achieving the user's goal consists of building an individual trajectory that ensures the formation of the necessary competencies. The conclusion of the decision is based on an integrated assessment of the material;
- a centralized storage of materials (repository) with the delimitation of access rights for users.

At the same time, compliance with information security is required.

It is advisable to organize the training of students in the conditions of an open educational resource after agreeing on the training program of specialists with the specialists of the university and forming a group of trainees. During the students' study of the material, they should be provided with teacher consultations and virtual seminars. Control can be ensured by performing tests and control tasks on studied topics. Final control and attestations must be carried out under the guidance of the persons responsible for the online course.

The implementation of open educational resources involves the use of various tools and platforms that help create, edit and distribute open-access educational materials. The following platforms are used to create and distribute OER. OER Commons is a global platform for creating, sharing and distributing open educational materials. Offers convenient tools for searching and storing resources. OpenStax offers free textbooks in various disciplines that can be edited, adapted and used in the educational process. MERLOT is a library of digital educational resources for teachers and students that allows them to add their materials. WikiEducator is a platform for creating open educational materials in wiki format, with the possibility of editing and sharing.

The following tools are used to create educational content. H5P is an online platform for creating interactive learning elements (quizzes, presentations, videos, etc.) and implementing them on websites or LMS. Google Classroom is a tool from Google for creating courses, tests, and assignments and working together with students. Canva for Education is a tool for creating visual materials (presentations, infographics, educational materials) that support collaboration with students.

Open content libraries are also used in the context of implementing open educational resources. Creative Commons is a platform for finding resources (images, texts, video, audio) with licenses that allow their free use and modification. Pixabay is a library of free images and videos that can be used as educational resources. Unsplash is a platform for finding high-quality photos that can be used to create educational materials.

You can place links to OER elements used in a higher education institution's online learning environment for ease of use. The tools listed above help create open educational resources and make them available to a global audience, contributing to the development of open education.

5   Results

Analysis of end-of-course grades (table 1) found a significant difference in the distribution of outcomes between the experimental and control groups ($\chi^2 = 45.55, p < 0.01$). In the experimental OER condition, a greater proportion of students achieved high marks (A/B grades), and fewer received unsatisfactory or failing marks compared to the control.

This finding aligns with meta-analytic results reported by Cho and Permzadian [9] showing that OER adoption is associated with higher average grades ($d = 0.17$) and course passing rates. It is also consistent with Suriano [25], who

Table 1. Levels of educational results in the control and experimental groups at the end of the experiment.

Grade	Experimental group		Control group	
	%	students	%	students
A	11.6	21	6.04	11
B	20.44	37	14.29	26
C	26.52	48	20.88	38
D	23.76	43	18.68	34
E	14.92	27	23.63	43
FX	2.76	5	14.68	30
Total	100	181	100	182

found OER significantly improved student performance in an introductory geography course.

Student feedback indicated that the curated OER were perceived as useful for self-paced learning, providing practice opportunities, and increasing engagement. Instructors noted that the resources enabled them to dedicate more class time to active learning and individual support. These qualitative insights echo the benefits of OER for personalized learning observed by Mosharraf [18] and Cubides et al. [10].

However, some challenges were encountered, including the initial time required to find and integrate suitable OER, student uncertainty about open licensing, and the need for ongoing curation to maintain relevant resources, mirroring issues raised by Flowers et al. [13] and Dneprovskaya et al. [12]. Strategies to mitigate these challenges are elaborated in the discussion.

6   Discussion

The positive outcomes observed in this study demonstrate the potential for OER to enhance student learning in applied domains like environmental engineering when adopted with a learner-centred approach. As articulated by Cubides et al. [10], the flexibility and adaptability of OER enable instructors to tailor content to their context and empower students in the learning process. The modular, multimodal nature of the OER used here supported self-directed exploration and skills practice.

Beyond replicating the general benefits of OER shown in prior research [9], this study offers insight into effective OER use for a specific discipline and student population. It illustrates how curating a range of OER types (videos, worked examples, e-texts) and mapping them to course outcomes can provide a rich, coherent learning experience, a model that may be useful for other engineering and applied science programs.

The challenges encountered point to the importance of institutional support and dedicated time for OER integration. Instructors need training to discover, evaluate and implement OER, supported by recognition in workload and evaluation [3]. Involving instructional designers, librarians, and media specialists

can ease this process [11]. Setting policies for licensing, accessibility and quality assurance of OER can build student and faculty confidence [17].

The sustainability of OER also emerged as a key issue, with the need for ongoing maintenance and updating [2]. Joining collaborative networks and contributing to shared repositories can make this process more manageable and multiply the benefits of OER creation [24].

Future research should explore how the efficacy of the OER-based model tested here may vary across student characteristics, course formats and institutional contexts. Examining impacts on motivation, self-regulation, and higher-order skills in addition to grades would give a fuller picture of OER-enabled learning [28]. Investigating practices for OER co-creation with students could further advance student-centred paradigms [8].

7   Conclusion

This study demonstrates the promise of OER for enhancing learning outcomes and experiences in environmental engineering education using a student-centred approach. Integrating diverse OER enabled instructors to support student needs better and promoted active, self-paced learning. The results strengthen the evidence base for OER efficacy and provide a model for discipline-specific deployment in an online environment.

Realizing OER's full potential will require investment in training, support, and infrastructure at the individual and institutional levels. By cultivating a culture of open practice and collaboration, higher education can harness the power of OER to make learning more engaging, equitable, and effective for all students. Future work should explore applications in additional domains and student populations to create accessible, learner-centred educational opportunities at scale.

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