The Challenge of OER in the Era of AI: A Transnational Intervention

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Abstract
The adoption of Open Educational Resources (OER) represents a turning point in democratizing access to knowledge and promoting innovative educational practices. The ENCORE project aims to integrate the use of OER with digital, green and entrepreneurial (DGE) skills through a system based on advanced artificial intelligence technologies. This study analyzes results of a transnational intervention aimed at assessing ENCORE's impact on increasing OER-related knowledge (OER Knowledge) and explores outcome variability across learner profiles and intervention types. The data collected shows a significant increase in participants' ability to identify, use and integrate OER in their educational settings, as well as an improvement in their understanding of open licenses and open educational practices. These findings highlight ENCORE's potential as a tool to facilitate access to OER, emphasizing the importance of course design in shaping learning outcomes and educational practices. ENCORE proves to be a valuable tool for enhancing professional development and promoting innovation. The article reflects implications for instructional design and the adoption of open AI-supported education.
Keywords: open educational resources, technology acceptance, AI-driven tools, open science, educational practices, DGE skills

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Introduction

The digital age is transforming the way education and society evolve and progress. Today, with an increasing abundance of resources, significant changes in educational strategies are occurring, and as a result of the sprint given by the COVID-19 pandemic and an era seemingly governed by smart technologies, educational systems need answers (García-Peñalvo et al., 2021). More recently, generative artificial intelligence (GenAI) has dramatically expanded the range of possibilities, increasingly "at the fingertips" of students and educators. This continuous change has intensified the need for adaptive and anticipatory approaches, including the integration of AI-driven tools such as ChatGPT (Tlili et al., 2023). While GenAI technologies offer new opportunities, they also require critical reflection on their human and educational impact. It is undoubtedly important to develop educational interventions and policies in step with the times. However, the urgency of having "a bigger picture" of technological change, through a more personal and critical reevaluation of central methods and issues, has remained equally firm.

There have also been numerous initiatives aimed at providing the tools and context necessary to understand and experience the effects of digital transformation on the workplace, education, and daily life. For example, the Digital Education Action Plan (2021-2027) was formulated to realign education and training to post-pandemic educational needs (European Commission, 2023). The Digital Competence Framework has been updated (Vuorikari et al., 2022), designed not only to explain how to access information today but also to become aware of the impact these resources can have on personal and professional lives. Above all, this concept is connected to the idea that every institution dedicated to lifelong learning must find the "right way" to implement openness, linking it to its own culture of learning and, in particular, to the concept of thoughtful professional development (Raffaghelli, 2014a).

These contemporary educational challenges require educators to reconsider their methods and pedagogical approaches, to shape interventions that effectively integrate technological advancement, environmental sustainability, and social resilience (Sancho-Gil et al., 2020; Selwyn, 2023; Parry & Metzger, 2023). The information landscape is thus undergoing a significant transformation, meeting the spread of the Open Education concept and the growth of Open Educational Resources (OER), which aim to "remove barriers and make learning accessible, abundant and customizable for all" (Inamorato dos Santos et al., 2016). As a key to quality education (Agenda 2030), Open Education emphasizes removing barriers, leveraging digital technologies, and connecting formal and informal learning to promote personalized, lifelong educational pathways (Inamorato dos Santos et al., 2016). This paradigm

promotes a culture of shared knowledge, enabling educators and students to adapt materials to specific contexts and create relevant and engaging learning experiences.

This vast repository of shared and reusable knowledge opens up numerous possibilities while introducing new challenges that must be addressed in the 21st century.

In this context, the ENCORE (Enhancing Competences to Open Up Education) Project (Ref. 101055893) is an innovative initiative that leverages advanced artificial intelligence technologies to promote the use of OER alongside the development of digital, green, and entrepreneurial (DGE) skills. By integrating these elements, ENCORE supports students, prospective educators, teachers, and trainers in designing learning pathways that respond to pressing global challenges such as digitalization, climate change, and post-pandemic economic recovery.

This study is the first of two complementary investigations into the outcomes of ENCORE-based interventions. Here, the focus is on the impact of Crash and Intensive Courses on participants' knowledge, awareness, and use of OER, intending to investigate the central hypothesis that ENCORE can be effectively embedded into institutional practices to promote OER through the lens of DGE skills. The second, complementary study explores participants' perceptions of the ENCORE system itself, examining acceptance, usability, and perceived usefulness. Taken together, these two investigations provide a comprehensive understanding of both the educational impact of ENCORE interventions and the factors influencing the adoption and practical integration of the platform in teaching practices.

2. Background

2.1 OERs

Central to the concept of open education is the OER, or Open Educational Resources. OERs are educational materials made freely available online under Creative Commons (CC) licenses, enabling users to retain, reuse, revise, remix, and redistribute these resources (Wiley & Hilton, 2018). This concept, established during UNESCO's 2002 Forum on Open Courseware, aims to democratize access to knowledge and empower learners globally. OERs encompass a wide range of materials, including textbooks, lesson plans, instructional videos, and even entire courses, promoting equitable access to quality education (UNESCO, 2002, 2011; Inamorato dos Santos et al., 2016). In recent years, their dizzying rise in teaching object repositories has offered

teachers a vast wealth of information and the ability to personalize interactions with students, without losing sight of the demands of an ever-changing technological landscape.

Initially seen as tools for broader accessibility, OERs have evolved to embody the philosophy of Open Education, which extends beyond the simple instrumental application of the resources themselves, connecting to the idea of institutional and individual collaboration and fostering an open and democratic community of practice. This philosophy positions OERs as a cornerstone for transforming educational practices, shifting from resource sharing to the integration of Open Educational Practices (OEP) that modernize and democratize learning environments (Ossiannilsson et al., 2020). Nonetheless, this transition remains a multifaceted process that requires careful consideration and reflection (Ossiannilsson et al., 2020).

The Joint Research Centre (JRC) introduced a comprehensive framework to promote the adoption of OER, defining Open Education as encompassing diverse applications, including OER, MOOCs, and open access (Innamorato dos Santos et al., 2016). This framework encompasses 10 dimensions of open education, promoting a holistic and transparent approach to practice. It encouraged educators to move beyond the mere creation and use of resources, fostering an approach that embraces openness in teaching and learning. From 2013 to 2018, the European Commission supported this vision through the Open Education Europa (OEE) platform, which disseminated research, including eLearning Papers, to advance the concept of Open Education. The conversation gradually shifted towards leveraging OER to support broader learning contexts, emphasizing learning as a dynamic and open process (Camilleri et al., 2012).

Further developments focused on implementing Open Education frameworks to aid educational design and teaching practices with OER (Elias et al., 2020; Padilla-Zea et al., 2022). Innovations such as micro-credentials and open digital badges also emerged, offering new ways to recognize and certify skills through portable digital evidence (Camilleri et al., 2012). Despite a decade of progress, the impact of OERs on student learning remains a key concern, with ongoing debates over their effectiveness (Wiley & Hilton, 2018; Kılıçkaya & Kic-Drgas, 2021).

Political support for Open Education continues to grow, driven by longstanding debates on its transformative potential to align education with the needs of the knowledge society (Innamorato, 2016; Stracke et al., 2020).

However, a more radical critique examines the very conceptual basis of open education, also exploring the digital architectures that support it (Villar-Onrubia & Marin, 2022). It still raises concerns, particularly after pandemics, about what extent open education is a driver of equity and social justice and

thus achieves the goals of globally available, accessible, and inclusive quality education (Veletsianos, 2020). Openness is not only about using open resources but also about engaging in a reflective pedagogical practice that transforms teaching and learning. It involves a sequence of individual decisions and an ongoing process of negotiation (Cronin, 2017). There is currently an attempt to understand what openness means beyond the performative idea of something readily available in a repository and what this implies for the professionalism and skills of educators.

2.2 ENCORE Approach

Despite these challenges, teachers play a vital role in ensuring the quality of education and student learning (Darling-Hammond et al., 2005, 2017). Improving teacher training, both initial and in-service, is widely recognized as a priority in international educational policies (OECD, 2005, 2019) and European strategies (European Commission, 2007; European Council, 2009, 2014, 2017, 2020).

In this context, teachers' Continuous Professional Development (CPD), also known as in-service professional training, is acknowledged as a key factor in enhancing the quality of education and learning (Caena, 2014; Darling-Hammond, 2005, 2017). Regularly updating teachers' skills is critical, especially in rapidly evolving contexts, where selecting and adopting high-quality resources for active teaching methodologies is key. Investing in innovative and effective CPD is therefore a strategic priority (United Nations, 2015).

For educational institutions, particularly universities, and organizations involved in adult education and open digital learning, professional development must go beyond traditional training courses. It requires providing educators with practical cases and resources to explore, experiment with, and reflect upon, fostering new approaches to tackle complex problems (Raffaghelli, 2014a, 2014b; Vladimirschi, 2018; Kuhn & Raffaghelli, 2023).

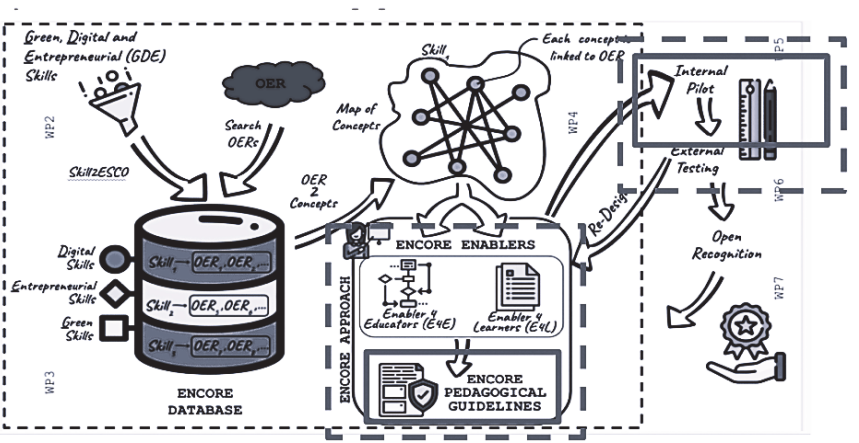
From this perspective, embracing the development of ecosystems for Open Education (OE) within the EU, the ENCORE Project emerges (https://project-encore.eu/). Among the various general objectives of the Erasmus+ program it seeks to pursue, the urgency to promote innovative and multidisciplinary approaches to teaching and learning stands out, as well as supporting and fostering innovation in the design and delivery of education and teaching methods.

ENCORE was conceived as an innovative system designed to enhance teaching and support the development of skills most influenced by emerging global trends. The platform leverages the knowledge embedded in Open

Educational Resources (OER), using artificial intelligence (AI) and natural language processing (NLP) techniques to identify, organize, and classify high-quality OER according to the relevant competencies of the ESCO framework (European Skills, Competences, Qualifications, and Occupations). A distinctive feature of ENCORE is its AI-powered interface, which integrates API-driven support based on large language models (LLMs) and generative AI (GenAI) to assist users in the design of learning scenarios. This intelligent support system enables educators to connect OER with specific competence areas, promoting deeper reflection on how education can address global challenges such as the digital transition, climate change, and post-pandemic economic recovery (Bucchiarone et al., 2023; Bucchiarone et al., 2024).

The ENCORE approach incorporates three key competence frameworks identified by EU policymaking as essential for lifelong learning and societal progress: Digital, Green, and Entrepreneurial (DGE). Through this integrated approach, the ENCORE project seeks to support students, future educators, teachers, and trainers in designing courses and learning pathways that connect educational objectives with the competences required to tackle global challenges such as digitalization, climate change, and post-pandemic economic recovery (Raffaghelli et al., 2023). Within this model, ENCORE promotes the use of OER in a collaborative human-machine environment (Figure 1).

Figure 1. ENCORE Approach



To make the most effective use of OER and enhance teaching, training, and learning, ENCORE enriches its holistic approach by selecting OERs starting from one's own educational or instructional design and by adopting a *design for objectives* model. In this perspective, content, resources, activities, and methods are deemed valid insofar as they align with the learning objectives. To support this objective-based design, various taxonomic classifications exist,

each characterized by different levels of complexity and articulation. The most widely used is Bloom's Taxonomy (Bloom, 1956). For the ENCORE project, Revised Bloom's Taxonomy (Anderson et al., 2001) was adopted to plan appropriate learning objectives. In brief, it distinguishes six main categories of objectives: remembering, understanding, applying, analyzing, evaluating, and creating. Each of these six levels involves different "cognitive processes" hierarchically organized to reflect increasing complexity and abstraction as one move from lower to higher levels. This taxonomy provides educators with a structured framework to design, deliver, and assess instruction, ensuring alignment with desired learning outcomes.

By embedding Bloom's taxonomy within the ENCORE platform, users are guided in designing clear, measurable objectives and in developing personalized learning scenarios tailored to their educational contexts. The taxonomy thus acts as a bridge between the definition of learning goals and the design of meaningful learning activities supported by OER.

Through this combination, the ENCORE project aims to guide students, prospective educators, teachers, and trainers in designing courses and pathways that connect learning objectives with the skills needed to address global challenges such as digitalization, climate change, and post-pandemic economic recovery.

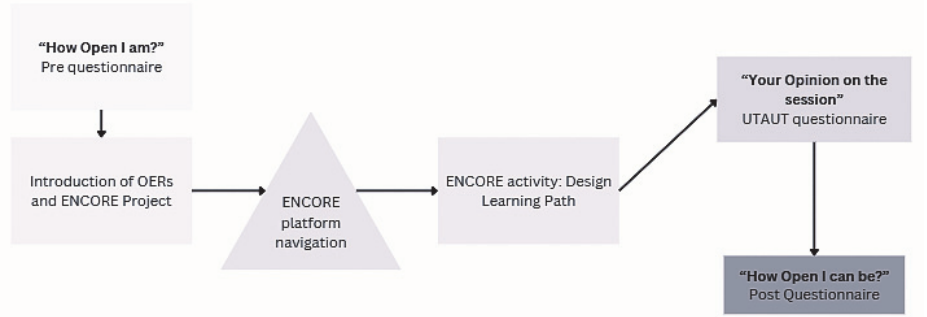
3. Methods

3.1 Context of Intervention

The study was characterized by a Design-Based Research (DBR) approach, which emphasizes iterative testing and refinement in real-world contexts. Within the ENCORE project, testing phases were organized to collect feedback and progressively improve the approach (Wang & Hannafin, 2005). This paper reports on the data collection from the transnational intervention carried out in two rounds, aimed at testing the ENCORE platform and refining its overall approach. About 7 preliminary sessions that we called "crash courses" and 8 additional sessions that we called "intensive courses" were delivered, in terms of participatory workshops and webinars co-designed with ENCORE project partners.

Through these initiatives, the ENCORE platform was tested in authentic educational settings to assess its usefulness in supporting innovative and collaborative learning practices. Following the two different cycles, the ENCORE approach was progressively applied, tested, and consolidated, as depicted below in Figure 2.

Figure 2 - Crash and Intensive Courses Approach



The first testing phase ("crash course") was an introductory and exploratory path aimed at familiarizing participants with OERs and the ENCORE platform and testing its potential to support the construction of a learning scenario. During this stage, participants used a scenario-design template to define learning objectives – drawing on verbs from the Revised Bloom's Taxonomy – describe their educational context, identify target learners and activities, and plan how to integrate DGE competences and OER found on the ENCORE platform. The feedback collected at this stage informed several improvements in usability and key features, especially regarding scenario design. Building on these results, the second phase tested the updated version in more authentic and collaborative educational settings. Here, with the taxonomy already integrated into the ENCORE platform, participants engaged in hands-on activities with OERs – designing, creating, and sharing their own materials – following a more practical path to reflect on openness and actively contribute to open knowledge.

Each workshop combined a theoretical introduction to Open Education, OER, and related policy frameworks with hands-on activities. After an overview of the ENCORE project and the role of DGE competences in learning design, participants selected one of three competence areas, explored relevant OERs on the platform, and used the platform's scenario-design tool to develop their own learning activities.

The study examines 15 interventions conducted among the project partners to collect responses on the effectiveness of ENCORE in promoting innovative teaching practices and supporting the integration of OER into educational practices. The findings will offer insights into how innovative platforms like ENCORE can enhance teaching and learning in the broader framework of Open Education and in response to global challenges.

3.2 Participants

This contribution focuses on the 15 interventions carried out between June

and December 2024, involving a total of 340 participants from Italian, Greek, and Spanish institutions in both higher education and vocational education and training (VET). A detailed breakdown of the anonymized sample is provided below.

3.3 Objective and Research Questions

While a related study from the ENCORE project (in press) focused on the acceptance, usability, and perceived usefulness of the platform among educators and students, the present study takes a complementary approach by examining the role of ENCORE in supporting the integration of OER into educational practices.

Building on the main working hypothesis that ENCORE can be effectively incorporated into educators' professional practice and institutional life as a tool to facilitate OER adoption, this contribution specifically aims to explore how the use of the ENCORE system affects educators' and trainers' engagement with OER, within the broader context of DGE competences. From this main working hypothesis, the contribution pursues the following two research questions (RQs):

- RQ1: How does participation in ENCORE-based courses affect educators' and trainers' knowledge, awareness, and use of OER in their teaching practices?
- RQ2: Are there observable differences in the effectiveness of ENCORE interventions depending on the participants' target group, level of prior exposure, or type of intervention implemented?

Focusing on ENCORE's practical role in supporting the integration of Open Educational Resources (OER), this study complements other project contributions on user perceptions and platform acceptance, offering a more complete view of the platform's educational value.

3.4 Research Design

The workshops themselves were structured with a theoretical and more practical part. To understand the impact of exposure to the ENCORE Approach on professional learning and identity related to knowledge and use of OERs, a self-test - named "How Open I Am" (ex-ante) and "How Open Can I Be" (ex-post) - was developed and administered at the beginning and end of the internal Crash and Intensive Courses. For transparency and clarity, the full version of the tool is presented in Annex 1.

The questionnaire was based on the self-reflection statements from DigCompEdu (Redecker & Punie, 2017; Council of the European Union, 2018)

and expanded through the Open Digital Framework (Inamorato D.S. et al., 2016). It focused on knowledge and use of OERs, licensing practices, implementation of Open Educational Practices, and understanding and contribution to Open Science. Separate versions were developed for educators and students, adapting the language accordingly.

Between these questionnaires, a theoretical session was held on OE and OERs, including the relevance of OE and DGE for educational design and activities. Subsequently, participants navigated the ENCORE platform, focusing first on the collection and creation of OER collections and then on learning path design.

The focus of this paper will be on the OERs questionnaires to detect increases in knowledge and perceived relevance of the Open project and culture to educational and professional practice.

The data collected from the questionnaires were analyzed at two different times to answer the two research questions, respectively. To answer RQ1, as will be seen below, a preliminary analysis of the sample distribution was conducted, including variables such as institution, location, intervention type, and target audience. Then, to assess changes in the distribution of scores, descriptive analyses were conducted between pre- and post-test results. To test the significance of these differences in distribution and determine whether or not the intervention had a significant impact on participants, the Wilcoxon test was used.

In response to RQ2, however, data was prepared and collected on other variables analyzed in the workshops:

- The type of target, based on the distinction between students, i.e., those who use the tool for study purposes; prospective educators, i.e., those preparing to enter the teaching profession, using the tool for initial training or skill development; and VET trainers, who use the tool for learning design or training;
- The level of exposure to the ENCORE system based on the different activities conducted, in terms of High (more than one session), Medium (120-180 minute session), and Low (60-90 minute session);
- and the type of intervention to which the data refer, in terms of “Crash course”, i.e., shorter sessions aimed at producing learning scenarios using the ENCORE system, and “Intensive course”, i.e., short, medium, or long approach to students' use of ENCORE, with no final production required.

From here, a multiple linear regression was conducted to estimate the relationship between two or more independent variables and a dependent variable. The regression model was constructed with the different predictors mentioned above and the final performance (post-test) as the response variable.

For transparency, the codebook with the relevant variables, adopted procedures, tools, and datasets is available in the Open Data repository (Raffaghelli et al., 2024).

4. Results

4.1 OER Knowledge

Concerning the first research question, before reporting the data analysis outcomes, an overview of the sample distribution analyzed will be provided (Table 1). A total of 340 responses were collected.

Table 1 - Distribution of the OERs test sample

Variables	Indicators	Freq	%
Institution	HIGHER-ED1	276	81,2%
	HIGHER-ED3	15	4,4%
	VET1	45	13,2%
	VET2	4	1,2%
Localisation	Italy	280	82,40%
	Greece	45	13,20%
	Spain	15	4,40%
Type of Intervention	Crash Course	183	53,80%
	Intensive Course	157	46,20%
Target	Prospective Educators	43	12,60%
	Students	293	86,20%
	VET Trainers	4	1,20%

Regarding OER Knowledge, a comparison of pre- and post-test data shows an increase in the average score from the initial phase (pre_OER: M = 2.846; post_OER: M = 3.463). The central tendency of the distribution also shifted upward (O1. Me = 3.00; O2. Me = 4.00), accompanied by reduced dispersion and greater consistency across most values.

Table 2 - Descriptive Analysis of OER Knowledge Pre- (left) and Post-test (right)

Question	Mean	Std.Dev	Question	Mean	Std.Dev
OER Knowledge Pre-test			OER Knowledge Post-test		
Q.1.1	2.97	1.10	Q.2.1	3.73	0.84
Q.1.2	2.73	1.01	Q.2.2	3.58	0.93
Q.1.3	2.88	1.15	Q.2.3	4.07	1.05
Q.1.4	2.23	1.06	Q.2.4	2.92	1.09
Q.1.5	2.68	1.10	Q.2.5	3.58	0.97
Q.1.6	3.05	1.07	Q.2.6	3.66	0.93
Q.1.7	2.18	1.07	Q.2.7	2.89	1.11
Q.1.8	2.88	1.08	Q.2.8	3.23	1.03
Q.1.9	3.30	1.07	Q.2.9	3.68	0.96
Q.1.10	3.10	1.02	Q.2.10	3.49	0.89
Q.1.11	2.75	1.02	Q.2.11	3.41	0.94
Q.1.12	3.02	1.02	Q.2.12	3.41	0.84
Q.1.13	2.32	1.00	Q.2.13	2.83	1.16
Q.1.14	2.77	1.25	Q.2.14	3.69	0.97
Q.1.15	2.49	1.08	Q.2.15	3.51	0.98
Q.1.16	3.42	0.98	Q.2.16	3.80	0.87
Q.1.17	1.98	0.99	Q.2.17	2.77	1.02
Q.1.18	2.88	1.13	Q.2.18	3.42	0.94
Q.1.19	4.45	0.70	Q.2.19	4.12	1.17

Specifically, in the pre-test (Table 2 - left side), the lowest values were recorded for creating and sharing OER (Q.1.4: M = 2.23, Me = 2.00), licensing practices for produced OER (Q.1.7: M = 2.18, Me = 3.00), familiarity with Open Science concepts (Q1.13: M = 2.32, Me = 2.00), and active contribution to Open Science (Q1.17: M = 1.98, Me = 2.00). Higher scores were associated

with recognizing open formats for faculty, researchers, and students (Q1.16: M = 3.42, Me = 4.00) and perceived relevance of open research and collaboration (Q.1.19: M = 4.45, Me = 5.00, std = 0.70).

Post-intervention (Table 2 - right side), all scores were generally higher with reduced data dispersion. The intervention appears to have had a positive impact on participants' perceptions and knowledge, as shown by improved responses to previously problematic questions. Notable improvements were observed in license identification (Q.2.1: M = 3.73, Me = 4.00), understanding OER terminology (Q.2.3: M = 4.07, Me = 4.00), proper referencing of OER (Q.2.5: M = 3.58, Me = 4.00), and recognizing Open Education principles in practice (Q.2.9: M = 3.68, Me = 4.00). However, familiarity with Open Science concepts (Q2.13: M = 2.83, Me = 3.00) and active contribution to Open Science (Q2.17: M = 2.77, Me = 3.00) remained relatively low.

The Wilcoxon signed-rank test was used to assess differences between pre- and post-OER groups, suitable for non-normally distributed data.

The test returned an extremely low p-value ($p < 2.2e\text{-}16$), indicating statistically significant differences. Despite this, the effect size was very small ($r = -0.012$), suggesting that the magnitude of the practical effect appears minimal, with a limited impact on the overall responses. Additionally, eta squared ($\eta^2 = 0.0382$) indicates that only ~3.8% of the total variability in scores is attributable to the difference between pre- and post-tests, implying that other factors may also influence participants' responses. While this value is significant, it suggests that the variability in the data is not primarily due to the difference between the groups but may also be influenced by other variables not considered in the analysis.

Analysis of the individual dimensions of the questionnaire – Know, Using, Adoption, OpenScience, Support, and Contribution – confirmed significant improvements across all areas, with p-values < 0.05.

4.2 Level of Impact

Regarding the second research question, in the preparatory phase, an attempt was made to test whether there were significant differences between two or more groups on a continuous variable. The Kruskal-Wallis's test was applied to explore differences in post-test scores (*post_total*) across three categorical variables:

1. Target (the recipients of the intervention: "Prospective educators", "Students" and "VET").
2. Level_Exposure (the level of exposure: "high", "medium", and "low").
3. Type_intervention (the type of intervention: "Crash course" and "Intensive course").

For Target, no statistically significant differences were observed in post-test results ($p = 0.3763$). From here, calculating the medians for groups to try to frame a summary indication of the distribution of groups concerning the continuous variable, prospective educators ($Me = 3.82$) performed slightly better than students ($Me = 3.47$), possibly reflecting the course focus and relevance to ENCORE skills. No data was available for VETs.

Regarding "Level_Exposure," data for the "Low" group were incomplete. Between "Medium" and "High" exposure, a significant difference emerged ($p = 4.225e\text{-}10$), with medium exposure participants scoring higher ($Me = 3.76$) than high exposure participants ($Me = 3.24$). This may reflect that longer or more intensive exposure encourages deeper engagement but also introduces greater complexity and caution in responses.

Finally, for "type_intervention", significant differences were observed ($p = 4.225e\text{-}10$). Participants in the "Crash course" group ($Me = 3.76$) generally scored higher than those in the "Intensive course" group ($Me = 3.24$), potentially due to the greater caution and criticality given by a longer time of activity and interaction.

At this point, a regression model was constructed including Type_intervention, Target, and Level_Exposure as independent variables (predictors) and post-test scores as the response variable.

The model showed no problems in fitting the data and was overall significantly useful in predicting post-test scores ($p < .001$). It then confirmed that intervention type significantly affected outcomes with the "Intensive" group scoring lower than the "Crash course" group (-0.515, $p < .001$). Differences by Target were not statistically significant, with Students scoring slightly lower than Prospective educators (-0.086, $p = 0.086$). The medium exposure level was excluded due to singularity (probably because the "medium" level of Level_Exposure was perfectly collinear with another variable in the model).

The model, however, explained only 23% of the variability in post-test scores, suggesting that there may be other variables not included in the model that explain a significant portion of the variability in scores.

An additional regression model including interactions between Type_intervention × Level_Exposure and Level_Exposure × Target confirmed that intervention type remained the only variable with a significant impact on post-test scores.

5. Discussion and Conclusion

The results will follow the two proposed research questions. Regarding RQ1

– *How does participation in ENCORE-based courses affect educators' and trainers' knowledge, awareness, and use of OER in their teaching practices*? – the findings indicate a significant improvement in OER knowledge between the pre- and post-test. The increase in the mean score (from M = 2.846 to M = 3.463) and the shift in the median towards higher values (from Me = 3.00 to Me = 4.00) suggest that the intervention had a positive impact on participants' perceptions and knowledge. Additionally, the reduction in data dispersion indicates greater consistency in responses after the intervention.

A more detailed analysis of individual pre-test questions immediately revealed critical areas, particularly concerning OER creation and sharing, knowledge of licenses, familiarity with Open Science, and active contribution to it. After the intervention, scores for all questions increased, with particularly notable improvements in the ability to identify licenses (M = 3.73, Me = 4.00), understanding OER terminology (M = 4.07, Me = 4.00), and correctly citing used OERs (M = 3.58, Me = 4.00). This demonstrates an increase in participants' awareness and knowledge following their engagement with ENCORE.

However, despite the overall improvement, familiarity with Open Science (M = 2.83, Me = 3.00) and active contribution (M = 2.77, Me = 3.00) remained among the least developed areas, suggesting the need for further targeted interventions to enhance these complex competencies. The initial positive results nonetheless indicate potential for further improvement through additional investigations. Inferential tests also revealed a significant difference between pre-and post-test groups ($p < 2.2e\text{-}16$). However, effect size analysis showed that, despite statistical significance, the magnitude of the difference was relatively small, suggesting the possible influence of other factors.

In this regard, an attempt was made to answer RQ2 – *Are there observable differences in the effectiveness of ENCORE interventions depending on the participants' target group, level of prior exposure, or type of intervention implemented?* – by exploring whether categorical variables such as participant target group, exposure level, and type of intervention influenced post-test scores. While no significant differences emerged across target groups, prospective educators scored slightly higher than students, likely reflecting prior familiarity with the relevant content, and given the specificity of some university courses considered. Medium-exposure participants (120-180 minute sessions) achieved higher post-test scores than high-exposure participants, potentially reflecting the balance between sufficient engagement and cognitive overload in longer interventions. Although greater exposure offered more time and opportunities for in-depth exploration of the concepts and the platform, it may have also prompted a more cautious and tentative approach, highlighting the need for further consolidation of the acquired knowledge. Similarly,

participants in Crash Courses scored higher than those in Intensive Courses, suggesting that concentrated, collaborative interventions may foster more immediate learning gains. Regression models confirmed the significance of intervention type, whereas target group and exposure level had limited predictive power.

The findings of this study underscore the potential of ENCORE-based interventions to enhance participants' knowledge and awareness of Open Educational Resources, aligning with broader trends in Open Education and digital transformation. The significant improvement in OER-related knowledge, particularly in areas such as license identification, terminology understanding, and correct citation practices, reflects the effectiveness of the ENCORE approach in fostering critical competencies for the digital age. These results resonate with the goals outlined in initiatives like the Digital Education Action Plan (2021-2027) and the updated Digital Competence Framework (Vuorikari et al., 2022), which emphasize the importance of equipping learners and educators with the skills needed to navigate and contribute to an open, collaborative, and technologically advanced educational landscape.

Critically comparing these findings with recent OER literature reveals both convergence and divergence. Consistent with prior studies (Inamorato dos Santos et al., 2016; Wiley & Hilton, 2018; Vuorikari et al., 2022), our results support the idea that structured, contextualized interventions can improve educators' knowledge and awareness of OER. However, in contrast to the idea emphasizing the benefits of sustained engagement over time, our findings suggest that shorter and more intensive interventions can yield immediate knowledge gains that are comparable to, or even exceed, those achieved through more extended learning schedules. This aligns with evidence indicating that learning outcomes depend more on the activation of key self-regulatory processes during instruction than on the mere duration of engagement (Sitzmann & Ely, 2011). Moreover, studies on learning design show that massed learning often yields higher initial performance than distributed approaches (Greving & Richter, 2021), although it may not support long-term retention or conceptual transfer to the same degree (McDaniel et al., 2013). Taken together, these results underscore the critical role of instructional design and learner engagement in shaping short-term outcomes, highlighting that the effectiveness of educational interventions may rely more on intensity and quality of engagement than on the overall length of participation.

However, the persistent gaps in familiarity with Open Science and active contribution highlight the complexity of these competencies and the need for targeted, ongoing interventions to address them. This aligns with the broader literature on Open Education, which stresses the importance of not only

providing access to resources but also fostering a culture of engagement and collaboration (Inamorato dos Santos et al., 2016; Wiley & Hilton, 2018).

A future study will focus specifically on this aspect of Open Science, investigating how participants' perceptions and engagement with Open Science evolve after a session more concentrated on OER and the ENCORE system, thereby closing the loop on the findings presented here.

From a pedagogical perspective, these findings suggest several practical implications. Educators and trainers designing OER-focused programs should carefully balance intensity and duration, align content with participants' prior knowledge, and include targeted modules to support complex competencies such as Open Science engagement. Attention to instructional strategies – such as collaborative activities, practical applications, and scaffolding of higher-order skills – can enhance the effectiveness of OER interventions and promote broader adoption within institutional practices.

Some limitations should be noted. Sample sizes were relatively small for certain groups (e.g., VET participants), and data for some exposure levels were incomplete. The modest effect sizes suggest that additional factors – such as prior experience with digital tools, institutional support, or participants' intrinsic motivation – may also have influenced outcomes. Future research could address these aspects by exploring longitudinal effects, evaluating the impact of specific pedagogical strategies, and examining OER adoption across diverse educational contexts, in order to better understand the processes underlying knowledge acquisition, engagement, and the integration of open practices.

In conclusion, this study shows that ENCORE-based interventions can effectively enhance participants' OER knowledge, especially when they are well-structured, focused, and aligned with learners' needs. While some competencies, such as engagement with Open Science, still require further development, the findings highlight the value of adaptive, evidence-informed approaches in fostering digital and open education skills. Overall, this research contributes to a deeper understanding of how targeted OER interventions can support educators and trainers in navigating the evolving landscape of open, collaborative, and digitally enriched education, offering practical insights for implementation and guiding directions for future inquiries.

Interventions that ensure relevance and meaningfulness in addressing the challenges and opportunities of the 21st century.

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Annex

Annex 1 - How Open I am? Full Questionnaire
Initial version of the Questionnaire: Juliana E. Raffaghelli
(upon the OpenEdu Survey for Self-Assessment https://joint-research-centre.ec.europa.eu/what-open-education/openedu-framework-and-guidelines_en;
https://publications.jrc.ec.europa.eu/repository/handle/JRC115663)

KNOWLEDGE OF OER
1. I can identify the license of an educational resource.
2. I can tag OER properly to increase the possibilities of others to reuse/find them.
3. I know what an Open Educational Resource (OER) is.

USING OER
4. I have shared and created OERs adapted from others.
5. I appropriately reference the OER I use (whether I adapt the resource or not).
6. I support my institution in the implementation of OER as an open education practice.
7. I openly license the OERs I produced.
11. I use OER to study through a personalised approach to the learning process.

OER TEACHERS' ADOPTION
8. I do not know whether my teachers have used Open Educational Resources for my learning.
9. I have seen the principles of open education in practice by teachers, e.g. using and sharing OER, using MOOCs and free and open online courses as support material or reference.
10. Besides applying the principles of OER in their teaching, I have seen my teachers take into account the access and accessibility of the teaching materials that I produce, in order to cater to those learners with special needs.
12. Generally, in my experience, the teachers adopt different OER in my teaching and support the institution to be more open to the learners.

ENGAGEMENT WITH OPEN KNOWLEDGE
13. I am not familiar with the concept of Open Science.
14. I understand basic concepts of open science and have consulted research shared openly.
16. I have seen open data and I can explain what it is.

UNIVERSITY SUPPORT TO OPEN KNOWLEDGE

15. The university where I study supports the teachers/researchers to publish openly, so we (students) can have access to the materials.

CONTRIBUTION TO OPEN KNOWLEDGE

17. I am an active contributor to open research projects and I am involved in communities that contribute to citizen science.
18. I support my institution in its effort to promote open research by engaging in my teachers' research projects or through the association of my thesis/project work with research activity.
19. I believe open research and collaboration are extremely relevant, whenever appropriate and feasible.

Data availability statement

The document and data used in this paper are publicly available in the following open data:
Raffaghelli, J. E., Foschi, L. C., Crudele, F., Doria, B., Cechinato, G., & Grion, V. (2024). Codebook - Educathons & Internal Piloting - ENCORE APPROACH [Data set]. Zenodo. https://doi.org/10.5281/zenodo.11431597.

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Conflict of interest

The authors declare no conflict of interest.

Ethics statement

The research was approved by the ENCORE partners. The data was anonymized, with pseudo-anonymization or complete anonymization of the identities of participants and institutions.