# Emerging risks in higher education: cross-national patterns of curriculum integration, learning gaps and digital competence

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**Abstract:** This study examines how emerging risk topics are addressed in higher education, drawing on the perspectives of faculty members and students from three European universities in Romania, Spain, and Ukraine. Using two parallel questionnaires, the analysis focuses on curricular coverage, perceived learning gaps, and self-reported digital competences related to the use of open educational resources (OER). The results indicate a moderate level of curricular integration. Topics related to the circular economy receive the greatest attention, while climate governance and green finance remain marginal in most study programs. Both faculty members and students report notable learning gaps, particularly in green finance, geopolitical risk, and cyber risk, despite increasing exposure to digital learning environments. Digital competences are generally assessed at a relatively high level, with students reporting greater confidence than faculty members, especially in relation to digital tools and online platforms. Cross-national differences emerge in curricular coverage, whereas variation in perceived learning gaps is observed mainly among students. Regression analyses reveal different patterns across groups. For faculty members, stronger digital confidence is associated with higher levels of curricular integration. For students, digital competences are more closely linked to the size of perceived learning gaps. Cluster analysis further identifies three educational profiles, highlighting the need for modular and multilingual OER tailored to different levels of preparedness.

**Keywords**: Open Educational Resources; green finance; geopolitical risk; cyber risk; digital competences

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## 1. Introduction

Higher education is currently shaped by multiple, intersecting pressures. Digital resources continue to expand, and universities are increasingly expected to integrate sustainability into established curricular frameworks and to address systemic risks such as climate change, geopolitical instability, and cyber threats. These demands complicate traditional approaches to teaching and raise questions about how curricula can

remain both relevant and adaptable. Open Educational Resources (OER) have emerged as one possible response to these challenges. They offer learning materials that can be modified, updated, and reused across institutional and national settings. Previous studies indicate that OER may support the development of cognitive and metacognitive competences by encouraging critical reflection and self-regulated learning (Yassin, 2024). The adoption of OER depends strongly on teachers' confidence with digital technologies and on how clearly their pedagogical benefits are recognized (Kuo & Kuo, 2025). This places teacher preparation at the center of the discussion. Without adequate training and institutional support, OER integration is likely to remain sporadic and driven by individual initiative rather than becoming a stable component of teaching practice.

As openly available educational resources continue to expand, managing and updating them has become increasingly demanding. Manual processes are often time-consuming and difficult to sustain. In this regard, artificial intelligence has been proposed as a tool for supporting the alignment of OER with evolving or newly defined taxonomies, helping to reduce the workload associated with resource maintenance (Li et al., 2024). While full digitalization remains challenging in many institutional settings, recent research shows that advanced computational models can deliver results comparable to those obtained through conventional approaches.

Experiences during the COVID-19 pandemic exposed several structural weaknesses in education systems. Teachers faced heightened levels of stress, uncertainty, and workload, alongside a growing range of professional responsibilities (Kim et al., 2022). Such conditions shaped how new pedagogical practices were received and implemented. The integration of OER and interdisciplinary content, therefore, appears to depend less on technological availability alone and more on the presence of supportive organizational environments.

In recent years, universities have intensified their efforts to integrate sustainability into teaching and learning. Participatory and experiential approaches are often highlighted for their capacity to help students engage with environmental and development challenges in more meaningful ways (Cornet et al., 2024). Such approaches, however, are not without difficulty. Curricular change frequently introduces tensions, particularly when methods challenge established teaching routines or require sustained collaboration among educators (Van Poeck et al., 2025). Interdisciplinarity plays a central role in addressing the complexity of contemporary global crises. At the same time, the literature offers no single, unified understanding of what interdisciplinary teaching entails, and reported practices and outcomes vary widely (Cohen et al., 2024). Within the broader agenda of the Sustainable Development Goals (SDG), attention has increasingly shifted toward meta competences, including systems thinking, normative reasoning, and relational capacity. These competences are not acquired automatically. They tend to emerge through deliberately designed interdisciplinary learning experiences (Bates et al., 2025).

Teaching on the circular economy illustrates the value of integrated pedagogical approaches. Focused training initiatives can substantially influence how students interpret and apply principles of circularity in real contexts (Ho et al., 2025). These effects, however, are uneven. The extent to which circular economy content is embedded in university curricula varies considerably across institutions and is shaped by governance arrangements and socio-cultural conditions, which in turn generate national differences in sustainability integration (Khajuria, 2025). Evidence from sustainability reporting in higher education points in the same direction. Many universities continue to approach sustainability through informal initiatives or fragmented practices rather than through coherent, institution-wide strategies (Son-Turan & Lambrechts, 2019).

Another key issue relates to the competences required in an increasingly globalized environment. Research on students' transition to higher education shows that early engagement with sustainability debates, especially when combined with activities that invite personal reflection, can strengthen students' connection to real problems (Keys & Heck, 2024). Teachers' responses to curricular change are less uniform. Reactions to top-down reforms range from acceptance to resistance and are shaped by prior experience, institutional roles, and professional expectations (Honkimäki et al., 2024). The literature points consistently toward the need for educational resources that are accessible and adaptable. Interdisciplinarity is particularly important in this respect, as emerging themes such as risk, uncertainty, and sustainability

rarely align with single disciplinary boundaries. For such resources to be effective, they must be embedded within curricular structures that support collaboration, encourage pedagogical experimentation, and foster the development of competences relevant to contemporary societal challenges.

## 2. Literature review

The development and use of open educational resources has become a central dimension of change in contemporary education. International initiatives frequently highlight their capacity to broaden access to knowledge, lower educational costs, and support more flexible teaching practices that respond to diverse learner profiles (Milošević et al., 2024). Beyond issues of accessibility, research points to the role of OER in curricular innovation, particularly through their integration into teaching materials in specialized and interdisciplinary fields. Attention is increasingly directed toward how such resources are selected, structured, and adapted to specific educational contexts. These processes play a decisive role in shaping the pedagogical relevance and overall quality of an OER and influence whether it can be meaningfully incorporated into existing curricula.

The adoption of open educational resources is influenced not only by institutional strategies but also by the characteristics of their users. Empirical studies show that students benefit from OER because these resources allow greater flexibility, support self-directed learning, and align more easily with individual learning rhythms (LeMire, 2024). For this reason, OER extend beyond their cost-saving function. They are increasingly understood as tools of inclusive pedagogy, capable of accommodating diverse educational trajectories and learning needs.

Universities have increasingly strengthened their commitment to sustainability education through the expansion of online and blended programs. Studies on online sustainability education emphasize that the transition to digital formats requires clearly articulated pedagogical objectives and closer alignment between institutional strategies and intended learning outcomes. They also highlight the need for transformative approaches that draw on student diversity and multilocal contexts as educational resources (Hakkarainen et al., 2024). Despite these developments, substantial challenges persist. Aligning curricular design with sustainability goals and ensuring consistent implementation across institutions remain ongoing concerns.

The integration of sustainability topics into curricula is shaped by both teacher autonomy and program-level structures. Research on curriculum making in climate change education shows that teachers often act at micro levels within broader curricular frameworks, with limited room for structural change. These frameworks are frequently overloaded and only partially updated to reflect issues such as the climate crisis, biodiversity loss, or pollution (Rushton & Walshe, 2025). Several barriers recur across studies. Sustainability themes tend to have low visibility in official curricular documents, time available for teaching is constrained, and access to freely available resources and institutional support remains uneven. Comparable challenges are observed in higher education, where the expectation to integrate emerging risks, digitalization, and sustainability places additional pressure on rigid curricular structures and shapes both teaching practices and educators' perceptions.

Interdisciplinarity is widely viewed as essential for understanding complex social and environmental phenomena. Integrated curricular approaches are often presented as a necessary condition for developing such understanding. At the same time, empirical research shows that students' capacity to engage with interdisciplinary content is shaped by individual characteristics, including openness to new experiences, need for cognition, extraversion, and international background (Schijf et al., 2025). This combination of structural and individual factors suggests that preparation for interdisciplinarity cannot rely on curricular design alone. It also requires learning resources that are flexible, adaptable, and modular enough to respond to diverse learner profiles.

The circular economy has become a prominent theme within sustainability education. Studies in higher education indicate that applied learning activities can increase students' awareness of their personal environmental impact and enhance their ability to propose practical solutions, such as strategies for reducing resource consumption on campus (Bugallo-Rodríguez & Vega-Marcote, 2020). Experiential projects addressing concrete challenges, including food waste reduction, further contribute to the

development of systems thinking, collaboration, and motivation for change. Their effects, however, are not always immediate or sustained, and short-term behavioral change remains limited in some cases (Ahmed et al., 2018).

Institutional tools and policy frameworks also play a decisive role in shaping sustainability education. Research on sustainability assessment instruments in higher education documents a wide range of frameworks that differ in scope, indicator design, and practical applicability (Pragya & Padmanabhan, 2025). This diversity places universities in a position where careful selection is required. The choice of assessment tools must align with institutional strategies and organizational culture, as it directly influences how emerging topics are prioritized and incorporated into the curriculum.

Several recurring patterns can be identified in the literature and provide a basis for the hypotheses advanced in this study. Teaching emerging risks and sustainability topics is closely connected to digital capacity, as these areas commonly rely on online resources, multimedia tools, and modular forms of OER. The extent to which such content is integrated into curricula varies across education systems. National policy frameworks, levels of technological infrastructure, and institutional culture appear to play an important role in shaping both curricular integration and teachers' digital competences.

Difficulties in understanding emerging risks are widely discussed in the literature, yet they tend to arise primarily at the individual level rather than as systemic shortcomings. As a result, perceived learning gaps often display similar patterns across national contexts. Preferences for open educational resources follow a comparable logic. Criteria such as flexibility, accessibility, and modular design recur across studies and are valued by educators regardless of country. These shared patterns offer a coherent conceptual foundation for the hypotheses examined in this study.

**H1**. A higher level of curricular integration of emerging risks predicts higher self-reported digital teaching capacity.

**H2**. Teachers from different educational systems exhibit significant variations in curricular coverage and digital competences.

**H3**. No significant cross-national differences are expected in teachers perceived learning gaps related to emerging risks.

**H4**. Teachers from different countries show similar preferences for modular and multilingual OER designed for risk teaching.

The growing societal and economic relevance of emerging risks, including climate change, geopolitical instability, uncertainties in green finance, and cyber vulnerabilities, has brought these themes to the forefront of higher education. Addressing them requires curricula that are regularly updated and teaching approaches that remain flexible. Such efforts are closely tied to digital competences, as instruction in these areas frequently relies on online platforms, multimedia tools, and open educational resources. Previous research suggests that educators who engage with interdisciplinary and evolving content tend to report stronger digital capacity, reflecting the demands of curricular integration in digitally mediated environments.

Against this background, the first hypothesis proposes a positive relationship between the level of curricular integration of emerging risks and teachers' self-reported digital capacity. Translating these topics into concrete teaching activities presupposes both familiarity with digital tools and openness to pedagogical innovation. At the same time, national context is likely to matter. Differences in curricular frameworks, technological infrastructure, professional development opportunities, and institutional culture may shape how emerging risks are addressed and how digitally prepared educators feel. On this basis, the second hypothesis examines whether significant cross-national differences exist in curricular coverage and digital capacity.

Patterns observed in the literature also inform expectations regarding perceived learning gaps. Difficulties in understanding emerging risks appear to stem largely from the inherent complexity of these topics rather than from institutional or national variation. Accordingly, the third hypothesis anticipates limited cross-national differences in teachers' perceptions of students' learning gaps. In parallel, modular and multilingual OER are consistently recommended for teaching interdisciplinary and emerging themes, largely due to their flexibility and adaptability to local contexts. In the absence of strong theoretical reasons

to expect systematic national variation, the fourth hypothesis assumes that teachers from different countries will express similar preferences for such resources.

## 3. Methodology

The study relied on two independent samples: one composed of university faculty members and the other of students enrolled in bachelor's and master's programs. Data were collected through an online questionnaire distributed to partner institutions in Romania, Spain, and Ukraine. Participation was voluntary and anonymous. The instrument captured respondents' perceptions regarding the curricular coverage of emerging risks, perceived learning gaps, digital competences, and preferences for multilingual open educational resources.

The questionnaire consisted of Likert-scale items rated from 1 to 5. Items were organized into three main domains: (a) curricular coverage of emerging risk topics, including circular economy, climate governance, green finance, geopolitical risk, and cyber risk; (b) perceived learning gaps related to these themes; and (c) digital capacity, measured for faculty members as self-reported competence and, for students, as characteristics of the digital learning environment they use. For each domain, a composite index was computed as the arithmetic mean of the corresponding items, following standard recommendations in scale construction (DeVellis & Thorpe, 2021):

$$\text{Index}=\frac{1}{m}\sum_{j=1}^{m} X_j . \tag{1}$$

where $m$ denotes the number of items in the subscale and $X_j$ represents the score for item $j$.

Internal consistency was assessed using Cronbach's alpha, calculated according to the conventional formulation (DeVellis and Thorpe, 2021):

$$\alpha=\frac{k}{k\text{-}1}\left(1-\frac{\sum_{j=1}^{k}\sigma_j^2}{\sigma_T^2}\right). \tag{2}$$

where $k$ is the number of items, $\sigma_j^2$ is the variance of item $j$, and $\sigma_T^2$ is the variance of the total composite score. Higher values indicate stronger internal consistency.

Cross-national differences were examined using one-way ANOVA models estimated separately for each composite index. The variable *Country* was derived from participants' self-reports. During data preparation, the category "Other" was excluded from inferential analyses because of its very small size, which could compromise variance estimation and statistical reliability. Consequently, the analyses focused on Romania, Spain, and Ukraine.

The ANOVA F statistic was computed as follows (Field, 2024):

$$F=\frac{SS_{between}/df_{between}}{SS_{within}/df_{within}}, \tag{3}$$

where $SS_{between}$ and $SS_{within}$ represent the between-group and within-group sums of squares, and $df_{between}$ and $df_{within}$ denote the corresponding degrees of freedom. Statistical significance was evaluated with reference to the F distribution.

Post-hoc comparisons between countries were conducted using independent-samples t-tests with Welch's correction. The test statistic was calculated as:

$$t=\frac{\bar{X}_1-\bar{X}_2}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}, \tag{4}$$

where $\bar{X}_1$ and $\bar{X}_2$ are the group means, $s_1^2$ and $s_2^2$ are the sample variances, and $n_1$ and $n_2$ are the group sizes. Degrees of freedom were estimated using the Welch–Satterthwaite approximation:

$$df=\frac{\left(\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}\right)^2}{\frac{s_1^4}{n_1^2(n_1-1)}+\frac{s_2^4}{n_2^2(n_2-1)}}. \quad (5)$$

To examine predictors of digital capacity among faculty members, multiple linear regression models were estimated. Digital capacity was predicted based on curricular coverage, perceived learning gaps, and country of origin, included as a categorical variable (Field, 2024):

$$DCIndex=\beta_0+\beta_1\cdot CoverageIndex+\beta_2\cdot GapIndex+\sum_c \beta_c\cdot Country_c+\varepsilon. \quad (6)$$

where the $\beta$ coefficients represent the estimated effects of each predictor and $\varepsilon$ is the error term.

Coefficients were estimated using the least-squares method, and statistical significance was assessed through *t*-tests. An analogous regression model was applied to the student sample, with year of study included as an additional categorical predictor.

Finally, to identify latent profiles in respondents' relationships with emerging risks and digital competences, a k-means cluster analysis was conducted using the Coverage Index (CIndex), Gap Index (GIndex), and Digital Capacity Index (DCIndex). All variables were standardized prior to analysis. Clusters were defined by minimizing squared Euclidean distances to cluster centroids (Everitt et al., 2011):

$$\min_{\{C_k\}}\sum_{k=1}^{K}\sum_{x_i\in C_k}\left\|x_i-\mu_k\right\|^2, \quad (7)$$

where $K$ is the number of clusters, $x_i$ denotes the standardized observation for participant $i$, and $\left\|x_i-\mu_k\right\|$ is the Euclidean distance to the centroid. The centroid for each cluster was computed as:

$$\mu_k=\frac{1}{|C_k|}\sum_{x_i\in C_k} x_i, \quad (8)$$

where $|C_k|$ is the number of observations assigned to cluster $k$. The distribution of clusters was subsequently examined by country to identify potential cross-national patterns of perceptions and competences.

## 4. Results

This section reports the findings of the quantitative analyses conducted on two samples: university faculty members and students from Romania, Spain, and Ukraine. The results describe patterns of curricular integration of emerging risk topics, perceived learning gaps, and digital competences. Cross-national differences and relationships among key variables are examined with a view to informing the development of open educational resources focused on emerging risks.

### 4.1. Sample characteristics

Table 1 provides an overview of the main sociodemographic and academic characteristics of the respondents, reported separately for faculty members and students. The table summarizes sample size, country distribution, academic roles among teaching staff, and years of study for students. This information offers the necessary context for interpreting the comparative analyses presented in the following sections.

Among faculty members, the distribution across the three countries is relatively balanced, with each group representing approximately one third of the sample. Academic ranks are dominated by associate professors and professors, while assistant and lecturer positions account for smaller proportions. In the student sample, Romania and Spain each account for roughly one third of respondents, with a slightly higher representation from Ukraine. Students are distributed across all years of study, with the largest share enrolled in the second year.

Table 1. Sociodemographic and academic characteristics of faculty and students

| Characteristic | Category | Faculty | Students |
|---|---|---|---|

| Sample size | Observations (N) | 101 | 315 |
|---|---|---|---|
| Country | Spain | 32.7 % | 32.0 % |
| | Romania | 30.7 % | 32.0 % |
| | Ukraine | 34.0 % | 35.4 % |
| | Other countries | 1.9 % | 0.6 % |
| Academic role | Assistant | 13.2 % | – |
| | Lecturer | 10.4 % | – |
| | Associate professor | 46.2 % | – |
| | Professor | 25.5 % | – |
| | Other roles | 4.7 % | – |
| Year of study | Year 1 | – | 17.7 % |
| | Year 2 | – | 34.2 % |
| | Year 3 | – | 21.4 % |
| | Year 4 | – | 21.4 % |
| | Other / unspecified | – | 5.3 % |

Note: Percentages may not sum to 100 due to rounding. Categories not applicable to a group are marked with "–".

Figure 1 illustrates the distribution of respondents by country for faculty members and students. The figure provides an overview of the sample composition and supports the validity of subsequent cross-national comparisons.

Among faculty members, respondents from Romania, Spain, and Ukraine are represented in relatively similar proportions, each accounting for approximately 30–34% of the sample. The category "OtherState" is marginal, with a share below 2%. A comparable pattern is observed among students. Spain and Romania each represent around one third of respondents, while Ukraine accounts for slightly more than 35%. The "OtherState" category remains negligible, below 1%.

This balanced distribution across the three countries supports the reliability of the comparative analyses. The very small size of the "OtherState" group further justifies its exclusion from inferential procedures in order to avoid distortions in variance estimation.

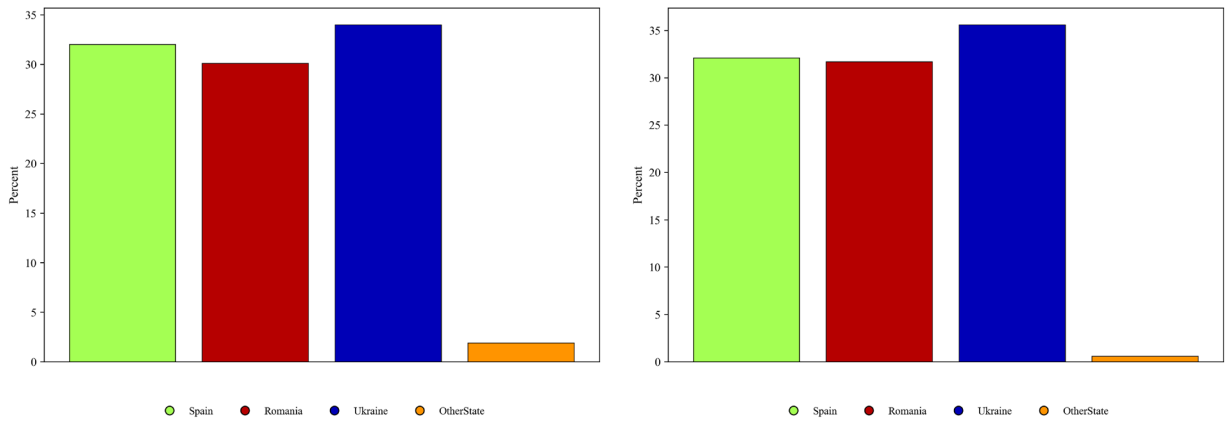



Figure 1. Country distribution of faculty and student respondents

## 4.2. Identifying thematic needs

Figure 2 shows how five emerging risk topics are reflected in teaching activities, as perceived by faculty members and students. These topics include the circular economy, climate governance, green finance, geopolitical risk, and cyber risk. The figure offers a general picture of current curricular exposure

and helps identify areas where additional learning resources may be needed.

Among faculty members, average scores for curricular coverage range from approximately 2.2 to 2.9 on the five-point Likert scale. The circular economy stands out as the most frequently addressed topic, while climate governance and green finance receive considerably less attention. Students report a similar distribution. Courses are most likely to include content related to the circular economy, whereas climate governance and green finance appear less often, with values close to those reported by teaching staff.

Our findings suggest a moderate presence of emerging risk topics in higher education curricula. Differences between faculty and student assessments are limited, and none of the themes appears to be consistently embedded across study programs. The areas with the lowest levels of coverage, particularly climate governance and green finance, are also among the most complex from a conceptual perspective. This combination highlights the need for additional educational support and more clearly structured learning materials that can complement existing courses.

The observed pattern of curricular integration is in line with the logic underlying hypothesis H1. Limited exposure to emerging risk topics may reflect constraints in digital pedagogical practice, but it may also reinforce those constraints by reducing opportunities for experimentation and instructional innovation.

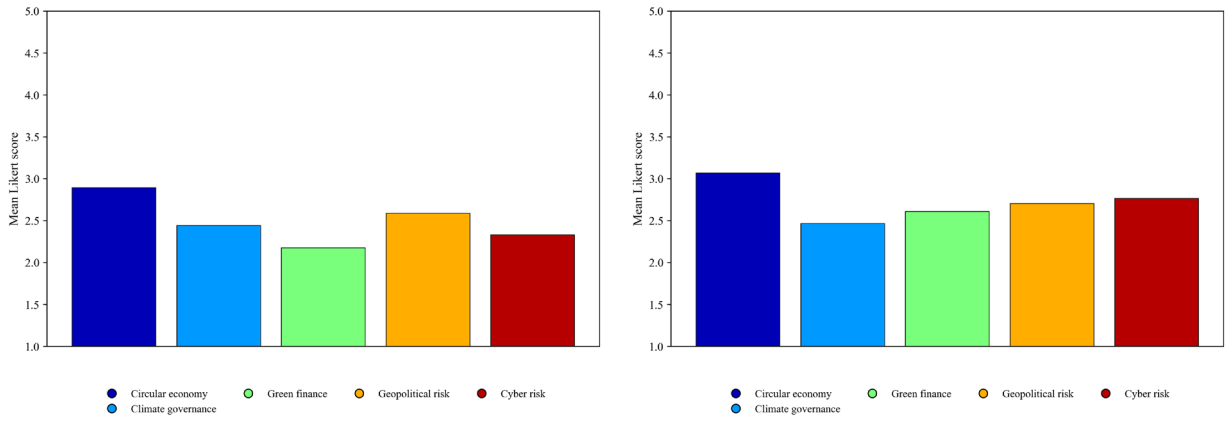



Figure 2. Average coverage of risk-related topics among faculty and students

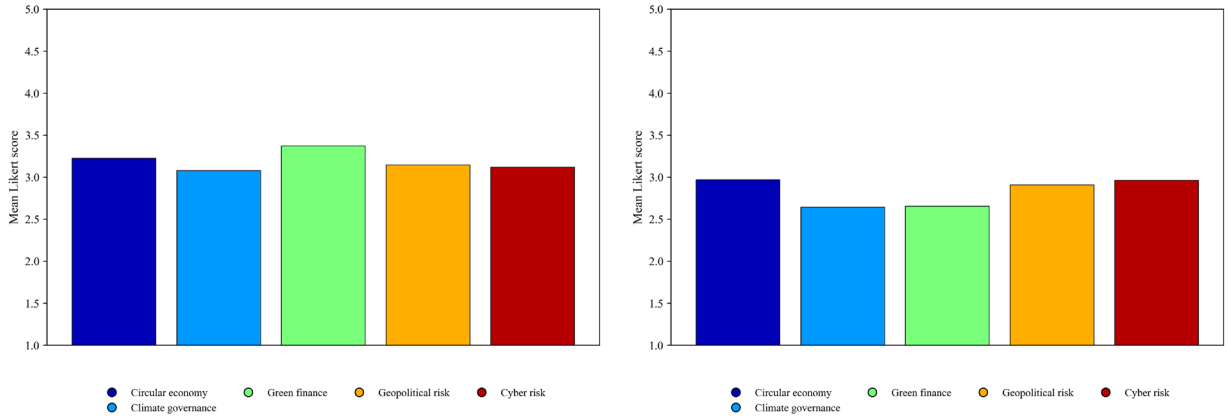
### 4.3. Learning gap

Figure 3 summarizes perceived learning gaps for the five emerging risk themes and offers insight into areas where respondents consider current levels of understanding to be insufficient. This analysis complements the findings on curricular coverage and provides a clearer picture of perceived educational needs among faculty members and students.

Both groups report moderate learning gaps, with mean values ranging between 2.7 and 3.4 on the five-point Likert scale. The highest gaps are associated with green finance, followed by geopolitical risk and cyber risk. By contrast, the circular economy records the lowest values, suggesting a comparatively stronger level of familiarity. The distribution of responses is similar for faculty members and students, and no substantial differences emerge in the ranking of topics.

These patterns point to a mismatch between exposure to certain emerging risk themes and perceived levels of competence. While the circular economy appears to be relatively well understood, areas such as green finance and cyber risk are more often associated with insufficient understanding and may require additional educational support. Consistent with hypothesis H3, cross-national variation in perceived learning gaps remains limited. This suggests that respondents across the three institutional contexts face comparable challenges when engaging with these topics.

The convergence observed across groups strengthens the case for shared educational solutions. Modular and multilingual open educational resources have the potential to address common learning needs and to support understanding in areas where gaps are most pronounced.




Faculty Student

Figure 3. Perceived learning gaps in risk-related areas

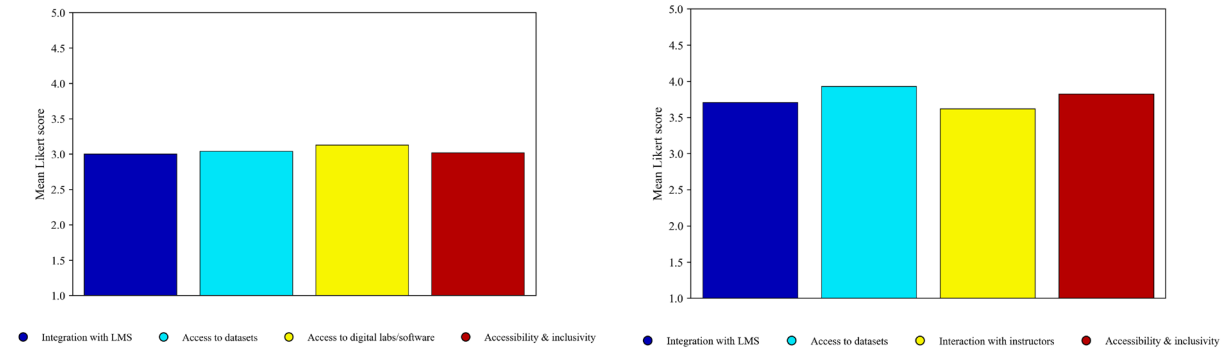
### 4.4. Digital capacity

Figure 4 summarizes the four components of digital capacity assessed in the study: integration within learning management systems, access to digital resources, innovation in teaching practices, and accessibility. The figure offers an overview of digital competences among faculty members and students and helps clarify their level of preparedness for using open educational resources.

Among faculty members, average scores range from 3.1 to 3.4 on the five-point scale. Higher values are reported for access to digital resources and for the use of institutional platforms. In the student sample, all four dimensions fall between 3.4 and 3.8, indicating a generally higher and more uniform level of digital competence.

Students report stronger digital competences than faculty members. This difference is likely related to more frequent interaction with digital platforms and online tools in their everyday academic activities. Higher levels of digital competence may facilitate engagement with open educational resources, particularly those that rely on interactive formats and online accessibility. The association between curricular exposure and digital competence is consistent with the logic underlying hypothesis H1.

The internal consistency of the digital capacity scale was examined using Cronbach's alpha, calculated separately for faculty members and students. The results indicate good reliability in both groups, with alpha values of 0.802 for faculty members and 0.878 for students. The higher coefficient observed among students suggests a more consistent pattern of digital platform use. These results support the use of a composite Digital Capacity Index in subsequent analyses.




Faculty Student

Figure 4. Mean scores for digital capacity items among faculty and students

Table 2 presents the mean values and standard deviations for the Coverage Index, the Gap Index, and the Digital Capacity Index for faculty members and students. The descriptive statistics reveal several consistent patterns across the two groups.

Students report higher values on the Coverage Index than faculty members, suggesting that they perceive emerging risk topics as more visible across their study programs. This difference may reflect students' exposure to a broader range of courses or a more holistic view of the curriculum. Faculty members, in contrast, are more likely to assess curricular coverage through the lens of their own disciplinary teaching.

Differences also emerge with respect to perceived learning gaps. Faculty members report higher values on the Gap Index than students, indicating that instructors tend to view students' understanding of emerging risk topics as more limited. Such assessments are consistent with the more critical perspective faculty members often adopt when evaluating complex or interdisciplinary content.

A similar contrast appears in the Digital Capacity Index, which is again higher among students. Although variability is comparable across groups, the difference in mean scores reflects students' greater familiarity with digital tools, easier access to online resources, and more frequent engagement with educational technologies. This pattern aligns with observations from digitally intensive learning environments and offers further support for hypothesis H1.

Table 2. Descriptive statistics for CIndex, GIndex and DCIndex among faculty and students

| Indicator | Level | CIndex | GIndex | DCIndex |
|---|---|---|---|---|
| Mean | Faculty | 2.486 | 3.188 | 3.047 |
| | Student | 2.723 | 2.829 | 3.769 |
| SD | Faculty | 1.054 | 0.986 | 0.889 |
| | Student | 1.156 | 1.076 | 0.886 |

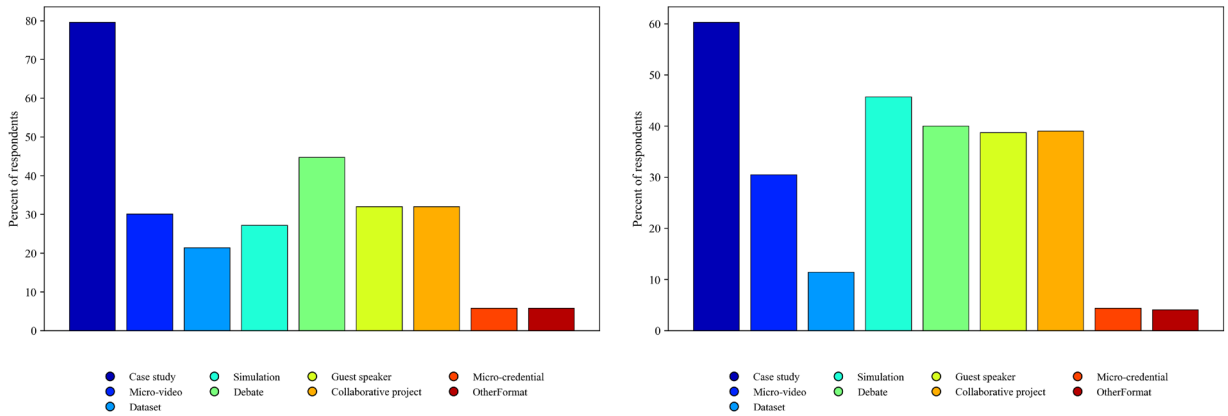
### 4.5. Preferences for teaching formats

Preferences regarding teaching formats provide useful insight for the design of open educational resources that can be applied across different national contexts. Figure 5 summarizes the responses of faculty members and students and highlights the types of learning activities they consider most effective.

Faculty members show a clear preference for traditional teaching formats, particularly lectures and seminars. Case studies and collaborative projects are also valued, although to a lesser extent. Students, by contrast, express stronger preferences for interactive and applied forms of learning. Case studies, practical projects, and simulations receive the highest ratings in this group. Both faculty members and students report limited interest in micro-learning formats and in activities delivered entirely online.

The responses point toward a shared interest in active learning approaches that emphasize application and interaction. This pattern suggests that the pilot OER should prioritize formats such as case studies, guided exercises, and applied scenarios that can be integrated into seminars or collaborative learning settings. Such preferences are consistent with the assumption underlying hypothesis H4, which anticipates similar expectations regarding modular and multilingual resources across countries.

These results are relevant for the practical development of the project outputs. They support an orientation toward OER formats that focus on concrete examples and activities rather than on predominantly theoretical materials.




Faculty Student

Figure 5. Preferred teaching formats among faculty and students

### 4.6. Barriers, linguistic support, and preferences for OER formats

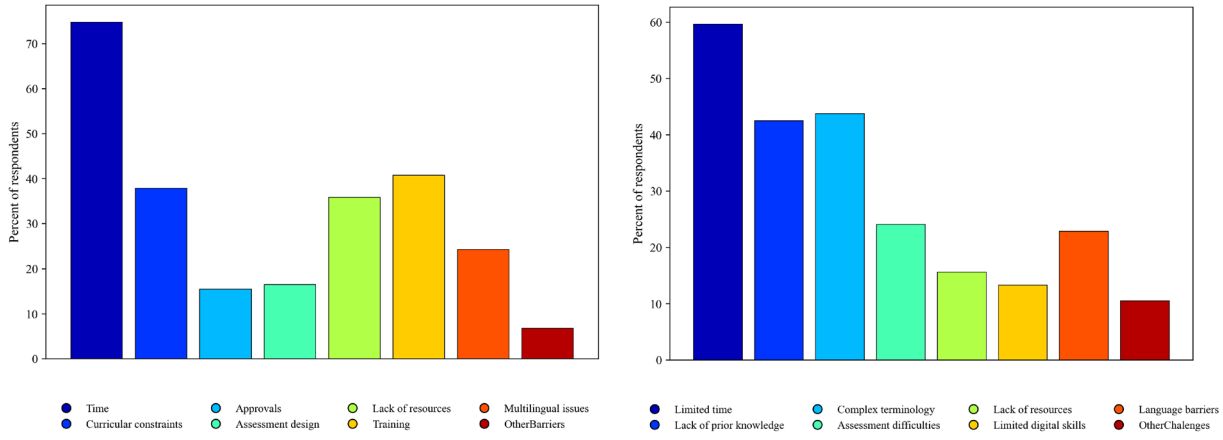
The analysis of perceived barriers in teaching and learning emerging risk topics, together with preferences for pedagogical and linguistic support, offers important guidance for the design of future open educational resources. Figures 6 and 7 summarize these results for faculty members and students.

Among faculty members, lack of time is the most frequently reported barrier, mentioned by 74.8 percent of respondents. Additional challenges include curricular constraints, limited access to resources, and difficulties related to training. Students describe a different set of obstacles. The most common difficulties reported in this group relate to insufficient prerequisite knowledge, concerns about assessment, and the conceptual complexity of emerging risk topics.

Clear patterns also emerge with regard to preferred forms of support. Both faculty members and students express strong preferences for slides, micro-lectures, and simulations. Linguistic support is considered particularly important. Subtitles are preferred by just over half of respondents, while full translations of materials are favored by slightly less than half. These responses point to the importance of providing flexible and multilingual resources that can accommodate varying levels of familiarity with emerging risk themes.

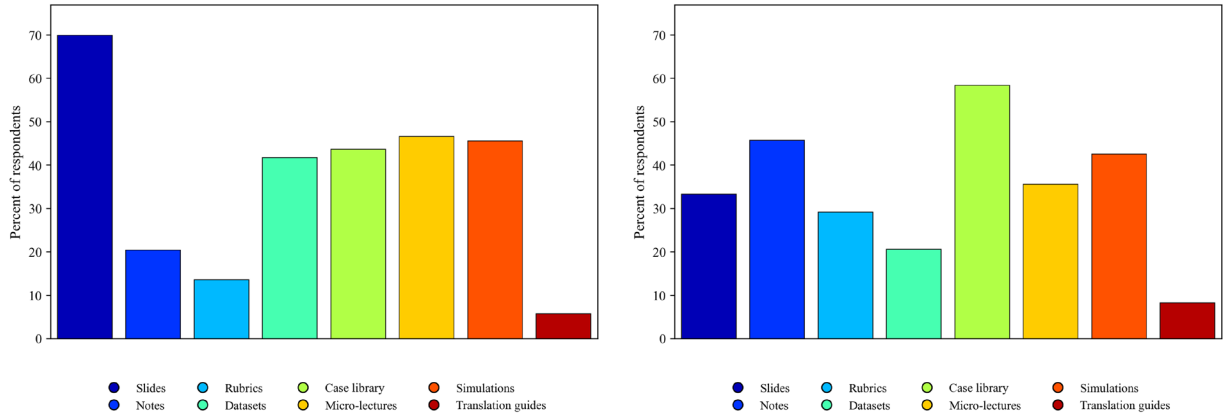
The reported barriers underline the need for concise and well-structured OER that can be easily integrated into existing study programs. This need is especially pronounced among faculty members, for whom limited time represents the primary constraint. For students, the main challenges are linked to limited prior exposure to emerging risk topics, suggesting the value of introductory components and applied examples that support the development of foundational understanding.

Preferences for slides, micro-lectures, and simulations further support the development of modular and visually oriented resources. The strong demand for subtitles and full translations reinforces the importance of a multilingual approach and aligns with the assumption formulated in hypothesis H4.




Faculty Student

Figure 6. Barriers to teaching and learning about emerging risks




Faculty Student

Figure 7. Preferred OER support features

### 4.7. Differences between countries

The comparison between countries allows a closer examination of how curricular coverage of emerging risk topics, digital capacity, and learning gaps vary across national contexts. Table 3 summarizes the results of the one-way ANOVA analyses conducted separately for faculty members and students.

Statistically significant differences are observed for curricular coverage in both samples. Among faculty members, variation across countries reaches significance ($F = 5.514$, $p = .002$), while among students the effect is stronger ($F = 17.530$, $p < .001$). Differences in digital capacity are also present in both groups, although the magnitude of these effects is more moderate ($p < .01$). In contrast, cross-national differences in perceived learning gaps are observed only among students ($F = 16.245$, $p < .001$). No statistically significant variation is found among faculty members ($p = .557$), suggesting more homogeneous perceptions within this group.

The results indicate that respondents from Spain consistently report same levels of curricular coverage of emerging risk themes compared with respondents from Romania and Ukraine. This pattern appears in both faculty and student samples and supports hypothesis H2. Differences in reported digital capacity further suggest that digital competences are influenced by institutional context and the availability of technological infrastructure. By contrast, faculty members' perceptions of learning gaps do not differ significantly across countries, which is consistent with hypothesis H3. Among students, however, variation in learning gaps suggests differences in exposure to, or familiarity with, emerging risk topics across educational systems.

Table 3. One-way ANOVA results for curricular coverage, learning gaps, and digital capacity by country

| DV (Index) | Group | Source | SS | df | F | p |
|---|---|---|---|---|---|---|
| **Coverage index** | Faculty | Country | 16.150 | 3 | 5.514 | 0.002 |
| | | Residual | 93.730 | 96 | - | - |
| | Student | Country | 42.548 | 2 | 17.530 | <0.000 |
| | | Residual | 376.213 | 310 | - | - |
| **Digital capacity index** | Faculty | Country | 9.873 | 3 | 4.518 | 0.005 |
| | | Residual | 69.925 | 96 | - | - |
| | Student | Country | 8.598 | 2 | 5.627 | 0.004 |
| | | Residual | 236.822 | 310 | - | - |
| **Gap index** | Faculty | Country | 1.986 | 3 | 0.696 | 0.557 |
| | | Residual | 91.360 | 96 | - | - |
| | Student | Country | 34.405 | 2 | 16.245 | <0.000 |
| | | Residual | 328.263 | 310 | - | - |
| Note: SS = sum of squares; df = degrees of freedom; *p* = probability value | | | | | | |

Additional detail is provided in Table 4. For both faculty members and students, statistically significant differences in curricular coverage are observed in comparisons involving Spain. Differences between Spain and Romania, as well as between Spain and Ukraine, are associated with negative t values and medium to large effect sizes. Comparisons between Romania and Ukraine, by contrast, are generally not statistically significant.

With respect to digital capacity, the most pronounced differences emerge between Romania and Ukraine, with effect sizes ranging from small to moderate. Differences between Spain and Romania are statistically significant but smaller in magnitude. The comparisons between Spain and Ukraine do not show a consistent pattern. These results point to variation in digital preparedness that may reflect differences in institutional practices and access to digital infrastructure.

For perceived learning gaps, statistically significant differences are again observed only among students. Comparisons involving Spain show moderate effect sizes, indicating higher perceived gaps relative to the other two countries. Among faculty members, none of the pairwise comparisons reach statistical significance. This suggests that instructors across the three countries share similar assessments of the areas in which students require additional support.

Tabel 4. Post hoc pairwise comparisons (Welch's t-tests) by country for faculty members and students

| Index | Group | Country pair | | $M_1$ | $M_2$ | t | p | $N_1$ | $N_1$ | d |
|---|---|---|---|---|---|---|---|---|---|---|
| Coverage | Faculty | Spain | Romania | 1.976 | 2.632 | -2.527 | 0.15 | 33 | 31 | -0.632 |
| | | Spain | Ukraine | 1.976 | 2.823 | -4.181 | < 0.01 | 33 | 35 | -1.014 |
| | | Romania | Ukraine | 2.632 | 2.823 | -0.696 | 0.489 | 31 | 35 | -0.172 |
| | Student | Spain | Romania | 2.275 | 2.686 | -2.709 | <0.01 | 101 | 100 | -0.382 |
| | | Spain | Ukraine | 2.275 | 3.168 | -6.471 | <0.01 | 101 | 112 | -0.888 |
| | | Romania | Ukraine | 2.686 | 3.168 | -2.898 | <0.01 | 100 | 112 | -0.399 |
| Digital | Faculty | Spain | Romania | 2.833 | 3.419 | -2.654 | 0.010 | 33 | 31 | -0.664 |
| | | Spain | Ukraine | 2.833 | 2.864 | -0.156 | 0.877 | 33 | 35 | -0.038 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Romania | Ukraine | 3.419 | 2.864 | 2.584 | 0.012 | 31 | 35 | 0.637 |
| | Student | Spain | Romania | 3.527 | 3.903 | -3.286 | <0.01 | 101 | 100 | -0.464 |
| | | Spain | Ukraine | 3.527 | 3.859 | -2.851 | <0.05 | 101 | 112 | -0.391 |
| | | Romania | Ukraine | 3.903 | 3.859 | 0.334 | 0.738 | 100 | 112 | 0.046 |
| Gap | Faculty | Spain | Romania | 3.297 | 3.077 | 0.826 | 0.413 | 33 | 31 | 0.207 |
| | | Spain | Ukraine | 3.297 | 3.280 | 0.085 | 0.933 | 33 | 35 | 0.021 |
| | | Romania | Ukraine | 3.077 | 3.280 | -0.770 | 0.445 | 31 | 35 | -0.190 |
| | Student | Spain | Romania | 2.398 | 2.858 | -3.164 | <0.02 | 101 | 100 | -0.446 |
| | | Spain | Ukraine | 2.398 | 3.202 | -6.062 | <0.01 | 101 | 112 | -0.832 |
| | | Romania | Ukraine | 2.858 | 3.202 | -2.295 | 0.023 | 100 | 112 | -0.316 |
| Note. $M_1$ and $M_2$ = group means; t = Welch's t statistic; p = probability value; d = Cohen's d; $N_1$ and $N_2$ = group sample sizes. | | | | | | | | | | |

### 4.8. Regression analysis

The regression analyses examine the relationships between curricular coverage of emerging risk themes, perceived learning gaps, and self-reported digital capacity. Ordinary least squares models were estimated separately for faculty members and students, and the results are presented in Table 5 and Table 6.

Among faculty members, curricular coverage emerges as the only significant predictor of digital capacity. Higher values on the Coverage Index are associated with higher self-reported digital competence ($\beta = 0.412$, $p < .001$). Other variables included in the model, such as country of origin, academic rank, and perceived learning gaps, do not show statistically significant associations. This pattern suggests that instructors who engage more frequently with emerging risk topics in their teaching tend to evaluate their digital competences more positively.

A different pattern is observed in the student sample. Here, perceived learning gaps are the main predictor of digital capacity ($\beta = 0.404$, $p < .001$). Students who report larger gaps in their understanding of emerging risk topics also report higher levels of digital competence. By contrast, curricular coverage does not display a meaningful association with digital capacity in this group. Country and year of study are likewise not statistically significant predictors.

These results point to distinct mechanisms across the two groups. For faculty members, digital capacity appears closely linked to the extent to which emerging risk topics are integrated into teaching activities. Addressing content such as the circular economy, geopolitical risk, or climate governance often requires engagement with digital platforms and tools, which may strengthen instructors' digital confidence. This finding is consistent with hypothesis H1.

For students, digital competences seem to be shaped more strongly by learning needs than by formal curricular exposure. Higher perceived gaps may encourage greater reliance on online resources, digital platforms, and self-directed learning strategies. In this sense, digital competence functions as an adaptive response to perceived limitations in curricular coverage.

Table 5. OLS regression predicting digital capacity (DCIndex) among faculty members

| Predictor | Coef. | Std. err | t | p value |
|---|---|---|---|---|
| Intercept | 2.437 | 0.360 | 6.762 | < .001 |
| Country: Spain | -0.292 | 0.204 | -1.429 | .156 |
| Country: Ukraine | -0.629 | 0.193 | -3.263 | .002 |
| Country: Other | 0.827 | 0.791 | 1.045 | .299 |
| Academic rank: Professor | -0.382 | 0.255 | -1.498 | .138 |

| | | | | |
|---|---|---|---|---|
| Academic rank: Associate professor | -0.361 | 0.231 | -1.562 | .122 |
| Academic rank: Lecturer | -0.298 | 0.317 | -0.940 | .350 |
| Academic rank: Other | 0.302 | 0.432 | 0.699 | .486 |
| Coverage index | 0.412 | 0.084 | 4.891 | < .001 |
| Gap index | 0.053 | 0.085 | 0.627 | .532 |
| Note. N = 100. $R^2$ = 0.358, Adjusted $R^2$ = 0.294. | | | | |

Table 6. OLS regression results predicting DCIndex for Student

| | **Coef.** | **Std. err** | **t** | **p value** |
|---|---|---|---|---|
| Intercept | 3.696 | 0.595 | 6.214 | < .001 |
| Country: Romania | -0.655 | 0.554 | -1.181 | .238 |
| Country: Spain | -0.884 | 0.555 | -1.593 | .112 |
| Country: Ukraine | -0.812 | 0.551 | -1.473 | .142 |
| Year of study 1 | -0.317 | 0.223 | -1.422 | .156 |
| Year of study 2 | -0.309 | 0.207 | -1.494 | .136 |
| Year of study 3 | -0.382 | 0.227 | -1.679 | .094 |
| Year of study 4 | -0.303 | 0.215 | -1.408 | .160 |
| Coverage index | 0.006 | 0.060 | 0.100 | .921 |
| Gap index | 0.404 | 0.063 | 6.383 | < .001 |
| Note. N = 313. $R^2$ = 0.271, Adjusted $R^2$ = 0.252. | | | | |

### 4.9. Clustering

A three-cluster k-means solution was applied separately to the faculty and student samples using the three core variables of the study: curricular coverage, perceived learning gaps, and digital capacity. The resulting profiles are illustrated in Figure 8. The purpose of this analysis was to identify distinct patterns of engagement with emerging risk education that cut across national and academic boundaries.

The results reveal three broad user profiles. One cluster is characterized by high levels of digital capacity and curricular coverage combined with low perceived learning gaps. This group represents a profile that is well prepared for working with advanced open educational resources and can be described as competent and well integrated. A second cluster displays moderate scores across all three dimensions. This intermediate profile constitutes the largest group and reflects respondents with some exposure to emerging risk topics and a reasonable level of digital competence, but with clear room for further development. The third cluster is defined by low curricular coverage and high perceived learning gaps, often accompanied by lower levels of digital capacity. This in-need profile highlights respondents who face greater barriers and would require more accessible materials, gradual progression, and additional forms of support, including linguistic assistance.

The identification of these three profiles has practical relevance for the design of future OER. Differentiating content according to levels of preparedness allows for more flexible learning pathways and better alignment with users' needs. The similarity of the clustering patterns observed among faculty members and students further supports the value of a modular approach that can address both instructional requirements and self-directed learning in a coherent manner.

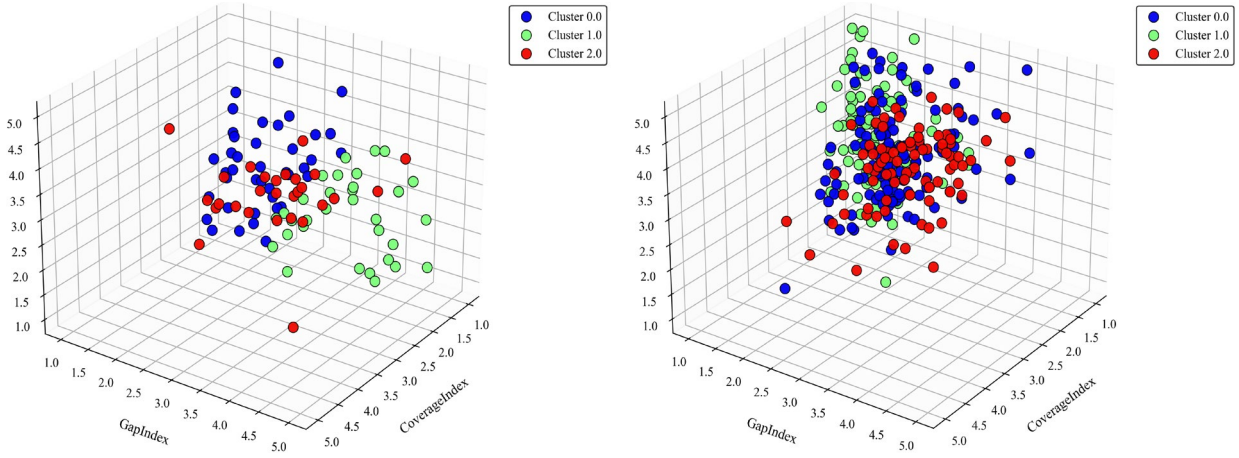



Figure 8. Three-cluster solution for faculty and student profiles based on curricular coverage, perceived learning gaps, and digital capacity. Cluster 0, "in-need"; Cluster 1, "intermediate" and Cluster 2, "competent and well-integrated" profile.

## 5. Discussions

The results shed light on how emerging risk themes are currently addressed in higher education. Topics such as the circular economy, climate governance, green finance, geopolitical risk, and cyber risk are present in teaching activities, but their integration remains uneven. Some areas are addressed more frequently, while others receive limited attention, despite their growing relevance. Curricular coverage is generally moderate, learning gaps differ across topics, and digital competences are relatively strong, especially among students.

This context creates clear opportunities for the development of open educational resources focused on emerging risks. At the same time, it raises important questions. Resources that are not aligned with users' needs, institutional settings, or everyday teaching constraints are unlikely to be adopted or sustained in practice.

### 5.1. Integration of risk themes and the relationship with digital competences

Among faculty members, a clear relationship appears between curricular coverage and digital competences. Instructors who report more frequent engagement with emerging risk themes also tend to evaluate their digital skills more positively. The regression analysis confirms this association, identifying curricular coverage as a significant predictor of digital capacity, while perceived learning gaps do not play a comparable role. This result lends support to hypothesis H1 and suggests a process of adaptation in teaching practice.

Working with complex and evolving topics often requires the use of digital platforms, multimedia content, and flexible learning materials. Repeated exposure to these demands appears to encourage instructors to broaden their use of digital tools and to develop greater confidence in their own competences. Earlier studies point in the same direction, showing that participation in the design and use of open educational resources can expand pedagogical repertoires and stimulate experimentation with digital technologies (Eka Putra et al., 2024).

The pattern is different among students. Here, digital competences are more closely associated with perceived learning gaps than with curricular coverage. Students who feel less confident about their understanding of emerging risk topics tend to rely more heavily on online resources and self-directed learning strategies, which may strengthen their digital familiarity over time. This response can be effective at an individual level. It allows students to navigate challenging content when formal instruction is limited.

However, such strategies have clear limits. Individual use of digital tools cannot substitute for coherent curricular integration. Topics related to risk and sustainability require explicit placement within study programs, along with structured guidance through open educational resources, if learning is to remain

consistent and equitable across different groups of students.

### 5.2. Cross-national differences and the influence of institutional context

The analysis reveals clear differences between national contexts in terms of both curricular coverage and digital capacity. Differences are also visible in digital competences. Participants from Romania tend to report higher levels of digital capacity than those from Ukraine, while Spain occupies an intermediate position. These patterns support hypothesis H2 and point to the role of institutional conditions in shaping how emerging risks are addressed in higher education.

Educational policies, access to digital infrastructure, and institutional culture appear to play an important role in this process. Universities operate within distinct national and organizational frameworks, which influence priorities, resource allocation, and openness to curricular innovation. Similar challenges are described in the literature on sustainability implementation in higher education, where resistance to change and fragmented responsibilities often limit the coherence of reform efforts (Aghajani et al., 2025).

A different picture emerges with respect to perceived learning gaps. Among faculty members, no significant cross-national differences are observed, which is consistent with hypothesis H3. Instructors across the three countries appear to share similar views regarding the areas in which students face difficulties.

The divergence between faculty and student perceptions is noteworthy. It suggests that teaching intentions and learning experiences do not always align closely. Addressing this gap requires greater attention to how emerging risk topics are introduced, supported, and revisited throughout study programs, as well as closer consideration of students' perspectives in curricular design (Watson et al., 2025).

### 5.3. Learning gaps, cognitive biases, and emerging risks

The analysis points to moderate learning gaps across all examined themes. The most pronounced gaps are reported in green finance, geopolitical risk, and cyber risk, both by faculty members and by students. By contrast, the circular economy emerges as the most familiar topic. This pattern aligns with previous research that describes the circular economy as a common entry point into sustainability education (Renfors, 2024).

Familiarity alone, however, does not guarantee deeper learning. Recent syntheses suggest that circular economy education leads to more substantial change only when it is integrated across multiple programs and linked to concrete industrial, social, and consumption-related contexts (Marcon & Sehnem, 2024). Without such connections, coverage may remain superficial, even when exposure is relatively frequent.

Learning gaps in geopolitical and cyber risk appear to be shaped by additional factors. These areas are closely associated with uncertainty, rapid change, and high levels of perceived threat. Research on cognitive responses to crisis situations shows that exposure to risk activates mechanisms such as ambiguity aversion, confirmation bias, and forms of cognitive self-protection (Frank et al., 2024). Such mechanisms may help explain why substantial gaps are perceived even when curricular coverage is not minimal.

Cyber risk represents a particularly critical case. Studies in higher education consistently report limited levels of cybersecurity awareness, both with regard to basic concepts and to the understanding of concrete risks and protective practices (Adeshola & Oluwajana, 2025; Djeki et al., 2024). The elevated learning gaps identified in this area are therefore not unexpected. They reflect broader educational shortcomings and reinforce the need for targeted interventions. Carefully designed open educational resources can play an important role here by breaking down complexity, addressing misconceptions, and supporting gradual skill development.

### 5.4. Preferences for learning formats and OER design

Preferences for teaching formats show a clear orientation toward active and applied learning. Faculty members continue to value lectures and seminars, while also attaching importance to case studies and collaborative projects. Students express an even stronger preference for interactive formats, particularly case studies, practical projects, and simulations. Interest in fully online delivery and micro-learning formats

remains limited in both groups.

This convergence suggests shared expectations regarding the design of learning resources. The results support hypothesis H4, indicating that preferences for modular and applied educational formats are largely similar among faculty members and students and remain consistent across national contexts. Learning activities that combine structure with practical engagement appear to be perceived as the most useful.

Similar tendencies are reported in recent studies on open educational resources in artificial intelligence education. Educators tend to favor modular materials that can be easily integrated into existing courses and adapted to different levels of prior knowledge (Rampelt et al., 2025). In the present study, the strong preference for slides, micro-lectures, and simulations reinforces the importance of flexible resource design.

Linguistic accessibility also emerges as a key concern. High demand for subtitles and full translations reflects the multilingual nature of higher education and aligns with broader recommendations that emphasize accessibility and inclusion as core principles of open education (Santos-Hermosa, 2024). From this perspective, effective OER need to be not only open and free, but also linguistically and culturally appropriate for diverse educational settings.

### 5.5. Implications for the Curriculum

The cluster distribution, which ranges from profiles with high curricular coverage and strong digital competences to in-need profiles marked by limited coverage and substantial learning gaps, has direct implications for teacher training and curricular planning. Research on initial and continuing teacher education shows that, despite growing attention to sustainability, thematic and methodological fragmentation persists and integration across training programs remains uneven (Blom & Karrow, 2024). Similar patterns are reported in studies on curriculum decolonization, where teachers are seen as important agents of change but continue to face institutional constraints, limited resources, and uneven engagement among colleagues (Papen & Atanasova, 2025).

Differences in the coverage of risk-related themes and in reported learning gaps also raise questions about equitable access to knowledge that is increasingly relevant in the context of contemporary crises. Evidence from climate education suggests that reliance on individual initiative, without broader institutional support, is insufficient for achieving lasting curricular change or for embedding issues such as climate justice in a systematic way (Rushton et al., 2025).

The need for clearer institutional frameworks is further supported by research on interdisciplinary teaching. Teachers often navigate tensions between learning quality and student engagement, between uncertainty and structure, and between inclusion and selectivity (Sørensen & Stenalt, 2025). Similar dynamics are visible in the present study. Faculty members emphasize the importance of materials that can be integrated into already crowded courses, while students express a preference for applied and exploratory activities that connect learning to real-world situations.

## 6. Conclusions

This study explored how faculty members and students from three European universities perceive the integration of emerging risk and sustainability themes into higher education curricula, their digital competences, and the potential role of open educational resources in addressing learning gaps. The results reveal a mixed situation. Universities show signs of adaptation, yet important vulnerabilities persist in their responses to environmental, economic, geopolitical, and cyber risks.

Curricular integration of emerging risk themes remains moderate. The circular economy receives greater attention, while climate governance and green finance are less frequently addressed. Both faculty members and students report notable learning gaps, particularly in green finance, geopolitical risk, and cyber risk. These gaps reflect a growing mismatch between the societal relevance of these topics and their current visibility in university curricula. Digital competences are generally well developed, with students consistently reporting higher levels. For faculty members, stronger curricular integration is associated with higher self-assessed digital competences. For students, digital competences are more closely linked to

perceived learning gaps, suggesting a compensatory reliance on digital tools when formal instruction is perceived as insufficient.

Cross-national differences further shape this picture. Respondents from Spain report lower levels of curricular coverage than those from Romania and Ukraine, while digital competences tend to be higher in Romania. Faculty members express broadly similar views on learning gaps across countries, whereas students in Spain report larger gaps. At the same time, preferences for teaching and learning formats show a high degree of convergence. Both groups favor applied and interactive approaches, such as case studies, collaborative projects, and simulations, alongside concise and modular resources that can be integrated into existing courses. Strong demand for multilingual and subtitled materials underscores the importance of a flexible and multilingual OER strategy.

These findings have direct implications for the development of open educational resources on emerging risks. Priority should be given to domains with the largest reported gaps, especially green finance, geopolitical risk, and cyber risk. OER need to be modular, adaptable, and oriented toward applied learning, using real-world examples and clear pedagogical guidance. Multilingual availability is essential to ensure relevance across institutional and national contexts. At a broader level, curricular integration of emerging risks requires coherent institutional support for digital competence development and for the systematic creation and adoption of OER. Without such support, innovation is likely to remain fragmented and dependent on individual initiative.

The study also has limitations. The reliance on self-reported data may introduce perceptual bias, and the samples, while balanced across countries, are not fully representative. In addition, the analysis focuses on perceptions rather than on direct measures of the impact of specific OER or curricular interventions.

Future research should move beyond perception-based approaches by designing and testing pilot OER on emerging risks within interdisciplinary programs. Longitudinal studies could assess their effects on digital competences, systems thinking, and student agency. Further work could also explore the role of university libraries and educational support units in co-developing OER in line with international recommendations, as well as the potential of simulations, serious games, and innovative digital platforms to support sustainable curricular change.

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