11th International Conference on Higher Education Advances (HEAd'25)
Universitat Politècnica de València, València, 2025
DOI: https://doi.org/10.4995/HEAd25.2025.19935

Navigating the Future of STEM Higher Education: Technological Innovations, Gender Dynamics, and Remote Assessment in Southern Europe

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How to cite: Soler, E.; Mas-Machuca, M.; Marimon, F. (2025). Navigating the Future of STEM Higher Education: Technological Innovations, Gender Dynamics, and Remote Assessment in Southern Europe. In: 11th International Conference on Higher Education Advances (HEAd'25). Valencia, 17-20 June 2025. https://doi.org/10.4995/HEAd25.2025.19935

Abstract

This study investigates the evolving landscape of remote assessment in STEM higher education, with a specific focus on Southern European institutions. The objective is to examine the impact of emerging technologies on online education, particularly in Spain, Italy, and Portugal. Employing qualitative methodologies, including expert interviews, the research explores the challenges inherent in STEM learning, necessary adaptations, and the long-term implications for educational practices. The method involves semi-structured interviews with experts, recorded and transcribed for thorough analysis. The results highlight the integration of new technologies in educational settings, addressing gender bias, and advocating for diversity and equitable participation. The findings contribute to the development of more inclusive, flexible, and personalized learning environments, emphasizing the importance of competency-based learning and critical thinking in preparing students for a technologically advanced future.

Keywords: *Remote assessment; Technology; future of Higher Education Institutions (HEIs); STEM; gender bias.*

1. Introduction

In the rapidly evolving landscape of higher education, the integration of remote learning in STEM fields has become increasingly important. This study examines the challenges faced by Higher Education Institutions (HEIs) in online education, with a particular focus on the impact of emerging technologies such as Generative Artificial Intelligence. Utilizing a qualitative methodology, the research involves semi-structured interviews with experts from Spain, Italy, and Portugal to explore regional variations in remote STEM learning. The study

comprehensively addresses the challenges and necessary adaptations in STEM education, while also anticipating long-term impacts on the educational landscape. Additionally, the research tackles gender bias in STEM degrees, promoting diversity and equal participation. By addressing these issues, the study aims to provide valuable insights for the evolution of educational practices, ensuring inclusivity and equity in the evaluation of student performance.

2. Literature Review

Online assessment tools in Higher Education Institutions offer numerous benefits, including instant feedback and enhanced learning outcomes (Jordan, 2023). Various forms of online assessments, from computer-marked evaluations to peer assessments, have shown potential in facilitating online learning experiences (Skliarova et al., 2022). The COVID-19 pandemic has further highlighted both the advantages and complexities of online education and assessment methodologies. Recent studies have explored the challenges and adaptations in STEM education within remote settings. MacDonald et al. (2020) emphasized the need for effective approaches across various educational levels. Gender bias remains a significant issue in STEM fields, affecting various aspects of academia and hiring practices. Recent research has further explored the impact of online learning on gender disparities in STEM education. Xu and Xu (2023) found that the transition to online learning during the COVID-19 pandemic exacerbated existing gender gaps in STEM fields, with female students reporting higher levels of stress and lower levels of engagement compared to their male counterparts. This highlights the need for targeted interventions to support female students in online STEM education. To address gender bias in STEM, Knezz et al. (2022) proposed embracing gender-blindness in hiring practices and implementing comprehensive strategies to foster diversity and inclusion. Building on this, García-Holgado et al. (2023) developed a framework for integrating gender perspectives into STEM education, emphasizing the importance of inclusive pedagogies and diverse role models. The future of STEM education lies in the effective integration of emerging technologies. Chung et al. (2023) explored the potential of artificial intelligence and virtual reality in creating more inclusive and engaging STEM learning environments. Their findings suggest that these technologies can help bridge gender gaps by providing personalized learning experiences and reducing implicit biases in assessment.

3. Method

3.1. Sample

To examine the perspectives of academics and managers from Higher Education Institutions (HEIs) in Spain, Italy, and Portugal, semi-structured interviews were conducted. Participants were selected through purposive sampling from four partner universities of the REMOTE

project, ensuring a broad representation of expertise in digital education and STEM assessment. Qualitative data collection took place from April to October 2023, during which a total of 37 interviews were completed. Each session lasted between 15 and 30 minutes and followed a standardized format in which respondents answered three predefined questions: 1) How do you imagine the university of the future?; 2) How will the students of the future differ from those of today?; 3) How do you think online/remote assessment methodologies might influence learning practices differently based on gender?… based on the typology of studies? Will it differ in STEM studies compared to others? The interviews were conducted and recorded virtually via Zoom, with a technician guiding the process question by question. The recordings were transcribed verbatim to ensure data integrity.

3.2. Gioia Method

The qualitative research was conducted using an adapted version of the Gioia Methodology (Gioia et al., 2012), which was essential for ensuring precise interpretative analysis and a comprehensive presentation of the research findings. The analysis involved initial coding of information extracted from interviews, organization of first-order themes into second-order codes, and finally, assembling terms and linking second-order codes into aggregate dimensions, creating a comprehensive framework for interpreting the research outcomes. The researchers conducted all coding using Atlas.ti.

4. Results

The analysis of the interview data revealed several key themes regarding the future of higher education, particularly in STEM. These themes were organized into aggregate dimensions.

Table 1. Aggregate dimensions of Question 1: How do you imagine the university of the future? Source: Own Elaboration

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
AI will play a significant role in the future of education; VR and AR technology will become mainstream in education; technology will undoubtedly follow this rapid pace of innovation and will give more opportunities to the teaching and learning process; within 20 years, the ongoing digital transformation that is already happening will continue to evolve; will be further disrupted by digitalization.	AI	Technology
	AR & VR	
	Technology	
	Digitalization	

The University of the Future will be a learner students' competencies centre, not focusing only on acquiring a grade; the focus will be on the knowledge that we acquire, but also on the skills, attitudes, and values that we develop as persons; what is more important will be critical thinking and how individuals should critically assess and analyze their overall environment.	Competency - Based	Competence Development
	Skills-Based	
	Critical Thinking	
Student-centered learning, student-centered assessment; instead of having this traditional lecture-driven model, the students will be at the center; it's no longer about passive education, it's more important than ever that higher education institutions give students the opportunity to get to know themselves deeper and better; learning modalities in higher education will need to be flexible, both in how and where students are learning; universities will increasingly adopt personalized learning approaches, tailoring education to individual student needs, considering their interests and learning styles.	Student - Centered	Student - Centered
	Personal Development	
	Flexibility	
	Personalization	
The current differentiation among universities, disciplines, types of students, intensity, and level of courses is already significant and will likely increase; a university will be mission-driven, focused on addressing global challenges that require the community to work collaboratively or in the best way to address them; the competition between universities will be very high. Universities without strong reputation may disappear in the future; universities will become more inclusive, not only in terms of people with disabilities, but also geographically; a different type of internationalization will emerge; smaller universities will cooperate with each other, cooperating in different countries; higher education institutions have survived for so many years because they have adapted.	Differentiation	Mission - Driven Institutions
	Mission-driven	
	Reputation	
	Competition	
	Inclusivity	
	Internationalization	
	Cooperation	

The future university will be significantly shaped by technological advancements, particularly in artificial intelligence (AI), augmented reality (AR), and virtual reality (VR). These technologies will drive the ongoing digital transformation, making education more student-centred, flexible, and personalized. Universities will prioritize the development of competencies, critical thinking, and skills-based learning, tailored to the individual needs of students. Additionally, there will be a marked differentiation among universities, with some focusing on mission-driven goals, inclusivity, and international cooperation. This evolution will ensure that higher education institutions remain adaptive and relevant in addressing global challenges and fostering a diverse and inclusive academic environment.

Table 2: Aggregate dimensions of Question 2: How will the students of the future differ from those of today? Source: Own Elaboration

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
They feel comfortable with artificial intelligence; students will demand and expect from institutions more technology-driven, immersive experiences to capitalize on their capacities and competencies; every institution has a learning management system, leveraging technology to receive assignments, grade students, and assess learning	Artificial Intelligence	Technology
	Technology-Driven	
A challenge for universities is adapting their program offerings to meet these demands without compromising the quality of education; they will anticipate tailored educational paths, adaptive learning technologies, and individualized support to meet their unique needs, interests, and career aspirations; a whole group of students will independently learn, gain skills, and apply those competencies in practice, developing a community of self-learners.	Adaptation	Personalization and Autonomy
	Personalization	
	Autonomy	
	Self-Learners	
Students may expect universities to offer more flexible programs and structures, including part-time options, online learning, and the ability to integrate personal and professional commitments; Institutions should provide students with micro-credentials, which are small pieces of learning	Flexibility	Flexibility
	Micro-credentials	
Adult learners will become more important in many places; older students will return to university while they are in the professional world more and more often than today; they will embrace lifelong learning as a must, recognizing the need to continually acquire new skills, new knowledge, and a path to evolving careers and industries	Adult Learning	Lifelong Learning
	Lifelong Learning	
	Re-skilling	
They pay to get the skills, competencies, and knowledge. So, they want to gain it now because they have ample opportunities to get information from outside sources and don't need to pay for it; but if there is a need to understand why something is being done and to develop strategic and critical thinking to improve the work being done.	Competencies	Skills and Competencies
	Skills	
	Critical Thinking	

Students will likely demand in the future more than now is to be more related to sustainability, ecology, and how to preserve the environmet; environmental sustainability and social responsibility will be significant concerns for future students; they will look for institutions that care for the well-being of students, including mental health and the appropriate services to support their academic journey; quality of life and well-being.	Sustainability	Sustainability and Well-being
	Social Responsibility	
	Well-being	

Future students will exhibit greater autonomy and will seek technology-enhanced learning experiences. They will demand personalized and flexible educational pathways, including part-time and online learning options. Lifelong learning will become a cornerstone of their educational journey, with continuous acquisition of new skills and knowledge being essential for career adaptability. The student demographic will become increasingly diverse, encompassing adult learners and individuals from varied socio-economic backgrounds. Moreover, future students will place a high value on sustainability and well-being, expecting educational institutions to address environmental and social responsibilities comprehensively. This shift will necessitate institutions to create inclusive, adaptable, and supportive learning environments.

Table 3: Aggregate dimensions of Question 3: How will online / remote assessment methodologies affect learning practices in STEM, differently depending on…Gender? Studies typology? Source: Own elaboration

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
With the artificial intelligence, there is a long way to go to fully integrate all of these features in the teaching and learning experience for students; there will be the possibility, with augmented reality, to simulate any kind of experiment or experience; virtual reality in laboratory activities is one of the challenges of the future; right now, discussions are taking place about the metaverse and how it can be used in learning and teaching in STEM.	AI	Emerging Technology
	AR	
	Virtual Reality	
	Metaverse	
Anonymizing informational personal data can likely help erase or make it more difficult for gender bias to exist, particularly in on-site evaluations. This approach could be an effective way to reduce potential gender bias; Online assessments can provide a more inclusive and equitable environment for female students in STEM, helping to mitigate gender bias that may exist in traditional	Gender Bias	Gender Bias
	Gender Bias Reduction	

classroom settings; Assessment and methodology, along with remote access to learning, are unlikely to differ. Over time, this will likely lead to greater equity between men and women in higher education, particularly in STEM.	Gender Equity	
The potential of teaching based on diversity factors might include gender, disabilities, location, or even times of the day. There is a huge spectrum of opportunities for different learning that online platforms facilitate; when talking about inclusion, this is one of the positive examples, providing accessibility and flexibility to different profiles of students, which stands as one of the missions of universities and society beyond these organizations	Diversity of Student Profiles	Diversity and Accessibility
	Accessibility	
In 20 years, each field of learning will likely have its own set of evaluation tools and methodologies, specifically designed to assess the skills, methods, knowledge, and competencies required for that particular field of study; AI and digital platforms will increase technological awareness and competencies of digitalization skills among learners; digital platforms will boost this type of course, engaging students more because the new generation, not only millennials and Generation Z, but the next generations to come, will be highly affected by technology and digital platforms.	Assesment of Skills	Skills and Engagement
	Digital Skills	
	Engagement of Students	

Online and remote assessment methodologies will likely impact learning practices in STEM fields differently based on gender and study typology. The incorporation of emerging technologies in STEM education can create more inclusive and equitable learning environments, potentially reducing gender biases. Online assessments can offer a more supportive setting for female students in STEM, helping to mitigate biases that are often present in traditional classroom settings. Furthermore, assessment methodologies in STEM will increasingly focus on practical application and problem-solving skills, while assessments in other fields may emphasize critical reflection and written communication. This differentiation will ensure that assessment strategies are aligned with the specific needs and characteristics of each field of study, promoting fairness and effectiveness in evaluating student performance.

5. Discussion and implications

This research highlights the transformative impact of digitalization and emerging technologies on higher education, particularly in STEM disciplines. Technologies such as AI, AR, and VR are making education more personalized, interactive, and inclusive. In line with Chung et al. (2023), our findings suggest that these innovations can help reduce implicit biases and improve student engagement. The COVID-19 pandemic has accelerated the adoption of hybrid learning models, combining online and in-person instruction to create flexible, student-centred pathways.

As supported by Jordan (2023) and Skliarova et al. (2022), the integration of digital assessment tools has improved efficiency and responsiveness in evaluating student performance. Our findings also reinforce the need for competency-based learning frameworks, emphasizing critical thinking, adaptability, and lifelong learning. These align with the views of MacDonald et al. (2020) on the importance of tailoring STEM education to evolving student needs. Future students will expect personalized, flexible learning pathways that integrate professional and personal development. One of the study's key contributions is its reflection on gender equity in STEM education. Echoing Xu and Xu (2023), we found that while online environments can exacerbate stress among female students, they can also offer more equitable spaces through anonymity and flexible participation. These observations support the proposals of Knezz et al. (2022) and García-Holgado et al. (2023), who advocate for inclusive pedagogies and systemic strategies to address bias. STEM assessments will focus on practical application and problem-solving, while other fields may emphasize critical reflection and written communication. This differentiation will promote fairness and effectiveness in evaluating student performance. In conclusion, the future of higher education will be defined by mission-driven and technology-focused universities. Future research should incorporate student perspectives.

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