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# Innovative Learning Environments in STEM Higher Education Opportunities, Challenges, and Looking Forward: A Book Review

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**ABSTRACT**

This study analyses the edited volume Innovative Learning Environments in STEM Higher Education, edited by Jungwoo Ryoo and Katherine Winkelmann (2021), in the context of advancing innovative learning practices in STEM higher education. This article employs a descriptive-critical book review approach to examine the book, focusing on its conceptual contribution, practical relevance, contextual applicability, organisation, and critical limitations. The book consists of several chapters each discussing different innovations in STEM learning, such as adaptive learning, multimodal learning, cross-reality (XR), and artificial intelligence (AI). The results reveal that the book emphasises a shift from teacher-centred to more student-centred learning by incorporating several innovative strategies, such as adaptive learning, multimodal learning, cross-reality (XR), and artificial intelligence (AI). In addition, the book outlines key implementation challenges, including constraints in infrastructure, institutional preparedness, and educators' competencies. Nevertheless, the discussion is largely focused on theoretical perspectives rather than practical applications and predominantly reflects experiences from developed countries, thereby limiting its relevance to developing contexts. Overall, the book offers valuable theoretical insights into contemporary trends in innovative learning; however, further empirical and context-specific research is needed to enhance its practical applicability in diverse educational settings.



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## 1. INTRODUCTION

There have been many changes in the field of education brought about by fast-growing technology, particularly within the STEM field [1]. In view of these developments, instructional approaches have become increasingly flexible and learner-centred rather than

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teacher-centred. In order to provide more interesting and significant learning experiences, the idea of creative learning environments has become more and more important. The book Innovative Learning Environment in STEM Higher Education by Jungwoo Ryoo and Katherine Winkelmann [2] highlights the various innovative methodologies in higher education, intending to enhance the quality of current learning, such as adaptive learning, multimodal learning methods, cross reality (XR), and artificial intelligence (AI). The book is an edited volume published by Springer, comprising several chapters by different contributors that discuss innovations in STEM higher education. The book is intended for educators, researchers, instructional designers, and higher education practitioners interested in technology-enhanced STEM learning. The relevance of reviewing this book is increasingly important in the era of digital transformation, post-pandemic higher education, rapid AI development, and the growing need for inclusive STEM learning environments [3], [4].

While these technologies have great potential, there is no doubt that a considerable discrepancy still exists between the conceptual theory and its practical implementation in the educational context [5]. Much of the current literature highlights the benefits of technology but does not address the problems that arise in its use, especially in diverse settings such as developing countries [6]. To determine the strengths and weaknesses of this book in providing innovative STEM education, a critical analysis is needed. This review aims to evaluate the book's conceptual contribution, practical relevance, limitations, and applicability in STEM higher education, particularly in developing-country contexts. To advance higher education practices, this review aims to offer a comprehensive analysis and to investigate how the concepts it presents might be used.

## 2. METHOD

The book Innovative Learning Environments in STEM Higher Education is examined in this study utilising a descriptive-critical method and a literature review methodology [7]. Content analysis of the book is conducted by examining its conceptual richness, structure, and significance in relation to current developments in STEM higher education. The analysis was conducted chapter by chapter and theme by theme by identifying the main ideas, innovative learning approaches, and educational issues discussed throughout the book. Descriptive analysis identifies key concepts in each chapter, while critical analysis assesses the book's strengths and weaknesses, particularly its theoretical underpinnings, practical application, and generalizability. The evaluation criteria used in this review include the scope and relevance of the book, conceptual contribution to STEM higher education, clarity of organisation, strength of theoretical arguments, practical applicability, attention to ethical issues, and relevance to developing-country contexts [8], [9].

In line with the purpose of this book review, the analysis also considers the alignment between the proposed innovations and the actual needs of learning in the digital era, especially in developing country settings. In addition to using the book as the primary source, this review also compares several arguments presented in the book with recent scholarly literature discussing STEM education challenges, digital learning transformation, and technology integration in developing countries [10], [11]. The analytical procedure involved several stages: reading the book comprehensively, identifying key themes, summarising

each chapter's contribution, evaluating the arguments' strengths and weaknesses, and drawing implications for STEM higher education practices. As a result, this method offers a critical evaluation of the book's contribution to comprehending cutting-edge teaching strategies in STEM education in addition to providing an orderly synopsis of the book.

## 3. RESULTS AND DISCUSSION

Innovation in Learning Environment in STEM Higher Education (2021), authored by Jungwoo Ryoo and Katherine Winkelmann, examines the inevitable impact of rapid technological growth on the education sector, particularly in STEM disciplines. According to Ryoo and Winkelmann [2], "Stakeholders in STEM higher education need to get creative in addressing the growing need for a diverse workforce in the US with a STEM background." This phrase suggests that the main forces driving educational transformation are external, particularly worker demands and technological advancements. Additionally, the book presents the idea of innovative learning environments as a basic framework that emphasises how learning processes can "enhance student engagement and learning experiences" through the use of technology (Ryoo & Winkelmann, 2021)[2]. As a result, the book seeks to present learning innovation as a blend of technology integration and pedagogical strategies. However, the book serves more as a theoretical framework than a practical manual for educators, as the discussion in this section is mainly conceptual and lacks concrete examples of real-world application.

The book shows how learning procedures can be tailored to each student's unique needs in the section on adaptive and personalised learning. This is emphasised in the statement that "personalised and adaptive learning is currently implemented in a variety of ways" (Taylor, Yeung, & Bashet, 2021)[2]. This method is applicable since it permits differentiated instruction and flexibility in the learning process. It also represents a paradigm shift toward more student-centred education [12]. However, rather than critically analysing its implementation issues, such as technical readiness, system complexity, and educator competence, the book's discussion tends to emphasise the potential and benefits of this strategy. This implies a propensity for intellectual optimism that is nevertheless out of step with the practicalities of teaching.

In terms of multimodal learning, the book explains that learning in the digital era is no longer limited to text but also involves various media such as audio, visuals, and video. The claim that "there exists a proliferation of information in several modes using a combination of modes can create multiple access points for learning" (Bouchey, Castek, & Thygeson, 2021)[2] supports this. The use of this strategy can be seen as extremely relevant to STEM education, especially in ensuring that learners acquire a better understanding of difficult and complex ideas [13], [14]. However, the book provides very little information on whether this strategy can effectively facilitate learning. Besides, the book does not outline a clear procedure for creating multimodal learning settings that do not overwhelm learners. This indicates that the book's contribution in this area remains more conceptual than practical.

In discussing the use of contemporary technology to enhance learning, the book mentions cross-reality (XR) technologies, including augmented reality (AR) and virtual

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reality (VR). According to Ziker, Truman, and Dodds (2021)[2], XR can help faculty members and learners "transcend the limitations of the classroom." Such technologies can potentially enable learners to have an extended experience. However, the book's analysis of XR typically emphasises its potential without critically examining implementation barriers such as poor infrastructure, high costs, and unequal access to technology. This implies a gap between the innovative ideas proposed and their practical viability.

Recent empirical studies also indicate that XR-related technologies, particularly augmented reality, may provide meaningful support for STEM learning by improving students' conceptual understanding, engagement, and reasoning ability. [15] showed that augmented reality integrated into problem-based e-modules can facilitate more interactive and contextual mathematics learning experiences. These findings suggest that XR technologies possess strong educational potential when supported by appropriate pedagogical design and technological readiness.

The conversation on artificial intelligence (AI) also emphasises how much potential it has to increase learning effectiveness [16]. AI has been used in a number of systems, including "autograders, chatbots, and automated essay scoring" (August & Tsaima, 2021)[2], showing that intelligent technology-based learning is starting to play a role in educational change. However, the ethical implications of employing AI, such as data privacy, algorithm openness, and potential prejudice, are not thoroughly covered in the book. This limitation is essential since the use of AI in education involves both ethical duty and efficiency.

Additionally, the book highlights that institutional preparedness and human resources are just as important to the success of learning innovation as technology. This is reflected in the assertion that implementing innovation "requires institutional support, infrastructure, and faculty readiness" (Ryoo & Winkelmann, 2021)[2]. This implies that learning innovation is a complex and multidimensional system. However, without providing specific implementation solutions, the conversation stays at the level of identifying these elements. As a result, the book does not adequately address the actual requirements of teachers when implementing cutting-edge teaching strategies.

The book's last section emphasises how crucial student viewpoints are to the creation of future learning. This is supported by the statement that "the most critical perspectives were the insights, thoughts, opinions, and hopes of the user population, the students" (Ryoo & Winkelmann, 2021)[2]. This suggests that in addition to being recipients of educational innovation, students are also significant providers. However, this approach remains essentially normative, as the book does not provide detailed guidance on specific techniques or strategies for actively involving students in the design of learning processes.

Table 1. Summary of the Main Themes Discussed in the Book

| Chapter/Theme | Main Argument | Strength | Limitation | Relevance to STEM Higher Education |
|---|---|---|---|---|
| Innovative Learning Environments | Learning innovation combines technology integration and student-centred pedagogy | Provides an interdisciplinary perspective on STEM learning innovation | Mostly conceptual discussion | Supports digital transformation in higher education |
| Adaptive and Personalised Learning | Learning can be adjusted based on student needs and learning pace | Encourages differentiated instruction and flexibility | Limited discussion of implementation barriers | Relevant for personalised STEM instruction |
| Multimodal Learning | Learning involves text, visuals, audio, and video | Improves conceptual understanding and accessibility | Lack of practical design guidance | Supports complex STEM learning processes |
| Cross Reality (XR) | XR technologies can transcend classroom limitations | Enhances immersive and experiential learning | Infrastructure and cost challenges are underexplored | Useful for simulation-based STEM learning |
| Artificial Intelligence (AI) | AI supports intelligent learning systems | Relevant to current educational technology trends | Ethical issues are insufficiently discussed | Supports automation and learning analytics |
| Institutional Readiness | Innovation requires institutional support and faculty readiness | Highlights organisational dimensions of innovation | Few practical implementation strategies | Important for policy and curriculum development |
| Student Perspectives | Students are important contributors to educational innovation | Encourages participatory learning approaches | Remains normative and less practical | Supports student-centred STEM learning |

The discussion presented throughout the book demonstrates that innovative STEM learning environments are not limited to technological adoption alone but also involve pedagogical transformation, institutional adaptation, and student engagement. The book successfully positions technology as a tool that can enhance learning effectiveness while simultaneously emphasising the importance of collaborative and learner-centred approaches [17]. These discussions are highly relevant to current developments in higher education, particularly in the wake of the acceleration of digital transformation and hybrid learning practices in post-pandemic education [18].

In addition, empirical evidence suggests that pedagogical transformation through STEM-oriented instructional design may significantly enhance student engagement and higher-order thinking skills. [19] reported that STEM-PBL-based e-modules effectively improved students' creative thinking in mathematics learning, indicating that innovative learning environments should integrate both technological innovation and learner-centred pedagogical strategies.

Another important strength of the book lies in its interdisciplinary scope, which integrates educational technology, STEM pedagogy, instructional design, and digital

innovation into one coherent discussion [20]. This interdisciplinary perspective enables readers to understand how emerging technologies, such as adaptive learning systems, XR technologies, and AI-based learning tools, may influence future STEM education practices [21]. Consequently, the book may provide useful insights not only for lecturers and researchers, but also for curriculum developers, institutional leaders, and policymakers involved in STEM education reform [22].

In addition, the discussion of adaptive and multimodal learning reflects current trends that emphasise flexible, personalised, and student-centred learning environments in higher education [23]. These approaches are considered highly relevant because STEM learning often requires visualisation, interaction, simulation, and differentiated instruction to support students' conceptual understanding and engagement. The integration of multimodal and immersive technologies may therefore improve learning accessibility and support diverse student learning needs in STEM classrooms [24].

Although the book explains many innovative concepts comprehensively, the discussion frequently prioritises theoretical perspectives over practical implementation strategies. Several chapters extensively discuss the potential advantages of technology integration but provide limited explanation for how educators may apply these innovations in institutions with unequal technological infrastructure, limited funding, and insufficient institutional support. This issue becomes particularly relevant in developing-country contexts, where challenges related to digital inequality, technological readiness, and educator competencies continue to affect the implementation of innovative STEM learning environments [18].

Furthermore, the book's discussion of artificial intelligence remains relatively limited in addressing ethical considerations associated with AI integration in higher education. Important issues such as data privacy, algorithmic bias, transparency, academic integrity, and unequal access to AI technologies deserve more comprehensive discussion because they directly influence educational decision-making and assessment practices [25]. Therefore, future studies concerning innovative STEM learning environments should not only emphasise technological effectiveness but also consider ethical responsibility, inclusivity, and contextual applicability across different educational settings.

**Strengths and Limitations of the Book**

Innovative Learning Environments in STEM Higher Education makes a significant contribution by providing an extensive overview of what is happening in STEM education in the digital era when viewed critically. AI, XR, multimodal learning, and adaptive learning are only some of the techniques that the author successfully incorporates within a logical framework in the book. The book enables readers to understand the relationships among these terms and offers a glimpse of where education is headed next. Although the book's conceptual strength is obvious, it pays more attention to theory than to practice. The implementation discussion is still very broad and offers little helpful guidance, especially when resources are limited.

Additionally, as most examples are from developed-country contexts, the ideas are less relevant to emerging countries that face a range of resource and infrastructure

challenges. Another disadvantage is that the ethical implications of incorporating technology into the classroom have not been well examined. Not enough attention is paid to crucial issues including algorithmic unfairness, data privacy, and an over-reliance on technology. Because of this, although the book is a strong theoretical resource, its relevance in real-world educational environments remains limited and warrants further investigation.

Nevertheless, the book remains highly valuable because it provides a comprehensive interdisciplinary discussion regarding emerging technologies and innovative pedagogical approaches in STEM higher education [18]. The integration of adaptive learning, multimodal learning, XR, and AI into one coherent framework enables readers to understand the direction of future educational transformation better. In addition, the book may serve as a useful theoretical reference for researchers, lecturers, curriculum developers, and policymakers interested in digital innovation and student-centred STEM learning environments [26]. Despite several limitations related to practical implementation and contextual applicability, the book still contributes significantly to the broader discussion of educational innovation in higher education.

## 4. CONCLUSION

The book Innovative Learning Environments in STEM Higher Education greatly expands the understanding of the transformation of STEM education in the digital age by providing a comprehensive conceptual framework that encompasses a variety of innovative approaches, such as adaptive learning, multimodal learning, the use of cross-reality (XR), and the integration of artificial intelligence (AI), all of which collectively reinforce a student-centred learning paradigm. The main contribution of this book lies in its discussion of innovative learning approaches and their relevance to STEM higher education, particularly in fostering more flexible, technology-enhanced learning environments. However, this book presents itself more as a theoretical and contemplative basis than as a useful practical guide for implementation. This limitation can be seen from the scarcity of real-world examples, the predominance of developed-country contexts, and the limited discussion of ethical and operational issues related to emerging technologies. Therefore, more empirical and contextual research is necessary, particularly in developing-country contexts, to support the practical implementation of technology integration in STEM education and to address challenges related to sustainability, accessibility, and ethical considerations.

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