Integrating XR Technology in Education: A Study on Enhancing Student Satisfaction through Sentiment Analysis

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ABSTRACT

Advancements in educational technology have brought significant transformations, particularly in online learning. The integration of virtual reality (VR), augmented reality (AR), and mixed reality (MR) into live classroom teaching represents a promising approach to enhancing student satisfaction. However, many educators continue to rely on traditional teaching methods, often resulting in monotonous and less interactive learning environments. This study aims to explore how the incorporation of XR technology in online learning can improve student satisfaction through sentiment analysis. The key outcome of this research is the development of an interactive XR-based learning platform that combines VR, AR, and MR technologies within live teaching practices. This platform is designed to enhance students' learning experiences and satisfaction in online environments. Employing a quantitative approach, the study analyzed student feedback using sentiment analysis software. Findings indicate that XR technology fosters greater engagement, interest, and comprehension among students, leading to higher levels of satisfaction. Furthermore, the results highlight the necessity for educators to be equipped with adequate knowledge and skills to effectively implement digital teaching strategies. The study recommends that educational policymakers and institutional leaders provide appropriate training and support to enable teachers to integrate XR technologies more effectively into their pedagogical practices.

Keywords: XR Technology, Online education, Student satisfaction, Sentiment Analysis, Educational Technology

INTRODUCTION

The rapid evolution of digital technologies has fundamentally transformed the landscape of contemporary education, reshaping pedagogical practices and redefining learner expectations (Selwyn, 2016; Anderson, 2019). Within this context, Extended Reality (XR), which includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has emerged as a disruptive force in higher education and online learning ecosystems (Radianti et al., 2020; Akçayır & Akçayır, 2017). Scholars have argued that immersive technologies not only extend the cognitive presence of learners but also foster heightened affective engagement, thereby enriching both individual and collective learning experiences (Merchant et al., 2014; Jensen & Konradsen, 2018). The integration of XR technologies into educational settings aligns with the broader paradigm shift from teacher-centered to learner-centered pedagogies, as emphasized in constructivist and experiential learning theories (Kolb, 2015; Vygotsky, 1978). By situating students in highly interactive and contextually relevant environments, XR enables multisensory engagement that bridges the gap between abstract knowledge and applied practice (Johnson-Glenberg, 2018; Hew & Cheung, 2014). Such affordances are particularly significant in online and blended learning modalities, where the absence of physical presence often undermines motivation, interactivity, and sustained attention (Hrastinski, 2019; Martin et al., 2020).

Despite these advantages, the adoption of XR in education remains uneven, with many instructors continuing to rely on traditional lecture-based models that may inadvertently constrain learner participation (Laurillard, 2012; Bates, 2019). Empirical studies suggest that student satisfaction, conceptualized as a multidimensional construct comprising cognitive, affective, and behavioral components, serves as a critical determinant of learning persistence, academic performance, and institutional reputation (Kuo et al., 2014; Moore & Kearsley, 2011). Consequently, examining the role of XR in enhancing student satisfaction through rigorous analytical methods is both timely and necessary (Alalwan et al., 2020; Bond et al., 2020). In this regard, sentiment analysis has emerged as a powerful methodological tool for assessing learner perceptions and emotions at scale (Feldman, 2013; Cambria et al., 2017). By systematically evaluating student-generated textual feedback, sentiment analysis provides granular insights into the affective dimensions of learning experiences that are often overlooked in conventional survey-based evaluations (Bozkurt et al., 2021; Zou et al., 2019). When applied to XR-based interventions, this approach not only illuminates the emotional valence of students' responses but also informs evidence-based pedagogical strategies aimed at fostering satisfaction, engagement, and retention (Shum et al., 2018; Rienties & Toetenel, 2016). Against this backdrop, the present study investigates the integration of XR technologies into online learning and evaluates their impact on student satisfaction through sentiment analysis. By situating the inquiry at the intersection of educational technology, learning analytics, and affective computing, this research contributes to the growing body of knowledge on immersive pedagogies while offering actionable implications for educators, institutional leaders, and policymakers in designing digitally enhanced learning environments (Ifenthaler & Yau, 2020; Zawacki-Richter et al., 2019).

LITERATURE REVIEW

XR Technologies in Education Affordances and Challenges

Extended Reality (XR), which encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), is increasingly recognized as a transformative innovation in education due to its immersive and interactive features that allow learners to engage with complex concepts through embodied experiences, thereby enhancing comprehension, retention, and motivation (Merchant et al., 2014; Radianti et al., 2020). For example, VR enables students to explore simulated environments, AR provides contextual information in real time, and MR integrates physical and virtual objects to foster experiential learning (Akçayır & Akçayır, 2017; Jensen & Konradsen, 2018). Despite these advantages, adoption of XR technologies remains constrained by challenges such as high implementation costs, limited access to technical infrastructure, and insufficient teacher preparedness (Bates, 2019; Laurillard, 2012), while some scholars argue that the novelty effect of XR may overshadow pedagogical objectives, producing only short-term engagement without sustained learning outcomes (Hew & Cheung, 2014; Hrastinski, 2019), thus highlighting the need for evidence-based evaluations that move beyond technology-centric discussions to focus on the genuine pedagogical impact of XR.

Student Satisfaction as a Multidimensional Construct

Student satisfaction has been consistently identified as a critical determinant of academic persistence, performance, and institutional credibility (Kuo et al., 2014; Moore & Kearsley, 2011), and is often conceptualized as a multidimensional construct encompassing cognitive (perceptions of learning effectiveness), affective (emotional responses to learning), and behavioral (willingness to engage) components (Alalwan et al., 2020; Bond et al., 2020). Within online learning, satisfaction becomes even more crucial as it directly influences motivation and reduces dropout rates (Martin et al., 2020), and the integration of XR into such environments has been shown to positively affect satisfaction by enhancing interactivity, personalization, and presence (Johnson-Glenberg, 2018; Radianti et al., 2020). Immersive learning experiences foster deeper engagement by shifting learners from passive content consumption toward active knowledge construction (Kolb, 2015), yet some studies caution that poorly designed XR applications may generate excessive cognitive load and diminish satisfaction (Selwyn, 2016; Jensen & Konradsen, 2018), underscoring the importance of pedagogically sound integration that prioritizes instructional objectives over technological novelty.

Sentiment Analysis in Evaluating Learning Experiences

Sentiment analysis has emerged as an increasingly valuable methodological tool in education, enabling large-scale evaluation of student perceptions and emotions through computational text mining (Feldman, 2013; Cambria et al., 2017). By systematically processing learner-generated feedback, sentiment analysis captures nuanced affective dimensions such as satisfaction, frustration, or enthusiasm that are often overlooked in traditional survey-based evaluations (Bozkurt et al., 2021; Zou et al., 2019). Within the context of XR-enhanced learning, this approach provides critical insights into how immersive technologies shape both cognitive and emotional experiences, allowing researchers and educators to assess whether novelty-driven engagement translates into sustained satisfaction and meaningful learning outcomes (Rienties & Toetenel, 2016; Shum et al., 2018). Nevertheless, limitations remain because natural language processing algorithms may misinterpret contextual subtleties such as sarcasm, cultural idioms, or mixed affective tones, which underscores the importance of triangulating sentiment analysis with qualitative and quantitative methods to ensure robust and valid interpretations (Cambria et al., 2017).

METHODOLOGY

This study adopted a quantitative research design that utilized sentiment analysis to evaluate student satisfaction in XR-integrated online classes, focusing on both polarity and lexical frequency to capture the affective dimensions of learner feedback. A total of 439 responses were collected from participants who attended XR-based online learning sessions, with data obtained through structured online forms distributed immediately after the sessions. Feedback entries were processed using sentiment analysis software that classified textual inputs into positive, neutral, and negative categories, assigning polarity scores ranging from 0, which indicated neutrality, to 1, which indicated strong positivity. The analysis was conducted in two stages, beginning with polarity classification, which revealed that 241 responses were neutral, 189 were positive, and only 9 were negative, followed by lexical frequency analysis that identified the most commonly used words such as “program,” “baik,” “manfaat,” “ilmu,” and “good,” which were subsequently visualized through word clouds to illustrate their prominence. The validity of the study was enhanced by triangulating polarity scores with word frequency analysis, reducing reliance on a single evaluative measure, while reliability was strengthened by employing automated tools that minimized human bias in classification. Ethical considerations were observed throughout the process, with all participants informed that their responses would remain anonymous and would be used solely for research purposes, ensuring compliance with academic integrity and participant confidentiality standards.

RESULTS AND DISCUSSION

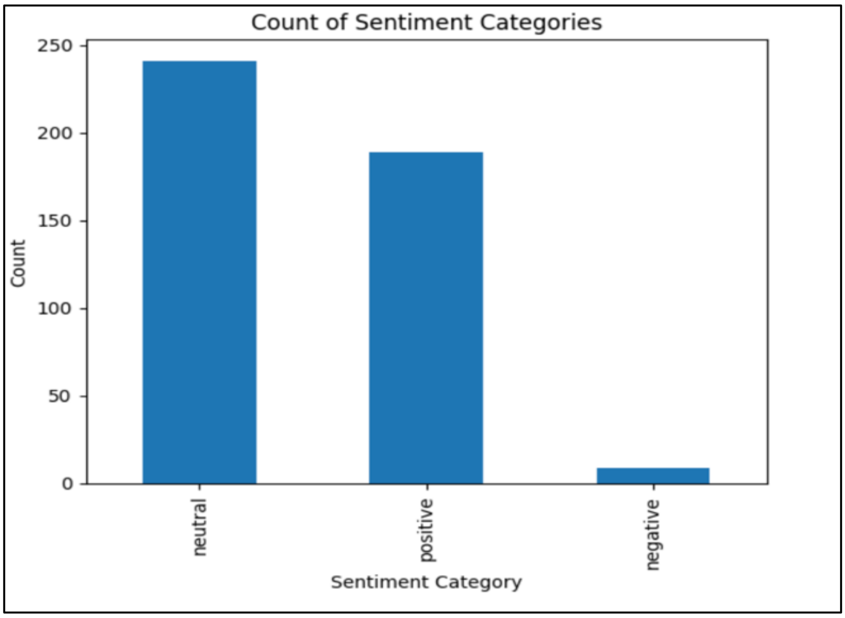

Figure 1: Distribution of Sentiment

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The analysis of 439 student feedback entries revealed that 241 were neutral, 189 were positive, and only 9 were negative, with sentiment polarity scores ranging from 0.35 to 1.0, the highest reflecting strong enthusiasm such as “Coach Nisha the best!” (score = 1.0), while neutral responses often comprised brief remarks like “tiada” or “ok” that indicated functional satisfaction without emotional intensity, and the few negative responses were mainly associated with technical issues such as sound clarity during delivery.

Table 1: Lexical Frequency Analysis

Word	Frequency
program	115
tiada	65
baik	55
manfaat	29
tarik	29
terima	27
kasih	26
serta	21
acara	20
ilmu	19
terus	17
good	14

Based on Table 1, lexical frequency analysis further reinforced these findings, with positive descriptors like *baik* (55), *manfaat* (29), *ilmu* (19), and *good* (14) appearing most prominently, alongside *program* (115), which reflected the holistic appreciation of the learning experience.

Figure 2: Word Cloud of the Review

The prevalence of affirmative terms, later visualized in word cloud form (as depicted in Figure 2), illustrated that learners valued not only the technological novelty of XR but also its ability to deliver beneficial and practical knowledge, a result consistent with prior studies linking immersive technologies to enhanced engagement and satisfaction (Radianti et al., 2020; Johnson-Glenberg, 2018). Importantly, the predominance of positive (43%) and neutral (55%) sentiment, with only 2% negative, suggests that XR integration was well received and did not create alienation or significant usability challenges, thus addressing long-standing issues of monotony and disengagement in online learning environments (Hrastinski, 2019). Nevertheless, the large proportion of neutral responses also signals that while XR was effective in sustaining attention and providing interactivity, further personalization and adaptive pedagogical scaffolding may be necessary to evoke stronger emotional resonance, as cautioned by studies on the potential of cognitive overload in poorly designed XR applications (Selwyn, 2016; Jensen & Konradsen, 2018). Overall, these findings underscore that the success of XR in enhancing student satisfaction depends not only on its immersive affordances but also on deliberate pedagogical integration that aligns with constructivist principles and ensures that technology serves as a medium for meaningful learning rather than as an end in itself (Kolb, 2015; Hew & Cheung, 2014).

CONCLUSION

This study explored the integration of XR technology in online learning and its impact on student satisfaction through sentiment analysis of 439 feedback entries. The results showed that most responses were positive or neutral, with only a few negative comments, suggesting that XR enhanced immersion, interactivity, and authenticity in the learning process. Lexical analysis highlighted affirmative words such as *baik*, *manfaat*, *ilmu*, and *good*, reinforcing the overall positive reception and confirming that learners valued both the novelty and the practical benefits of XR. Theoretically, the study contributes to immersive pedagogy by extending constructivist and experiential learning frameworks into digital contexts and by demonstrating the usefulness of sentiment analysis as a tool to capture affective aspects of learning often missed by surveys. Practically, the findings emphasize the need for educators to integrate XR with clear instructional goals and adaptive activities rather than relying on novelty alone. At the policy level, the study highlights the importance of investment in infrastructure, institutional support, and teacher training to ensure effective and equitable XR adoption. Despite its contributions, the study acknowledges limitations such as the reliance on sentiment analysis tools that may misinterpret context, the restricted scope of data, and the absence of longitudinal outcomes. Future research should therefore expand to different disciplines, apply mixed methods, and examine not only satisfaction but also learning achievement and skill development. Overall, XR shows strong potential to transform digital education, but its long-term success depends on sound pedagogy, institutional readiness, and sustained policy support.

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