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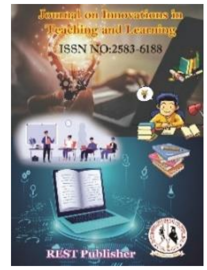

Comprehensive Evaluation and Ranking of Technology-Enhanced Learning Methods: A Comparative Analysis *

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Abstract: *The successful creation of interactive learning environments (ILE) in the field of technology-enhanced learning (TEL) relies significantly on effective design. Designing these environments involves input from a variety of experts, necessitating collaboration among individuals developing tools to tackle design challenges from various viewpoints. This article seeks to comprehensively analyze recent research that explores diverse approaches to improve technology-driven learning environments. The objective is to evaluate how well these approaches are practically applied to fulfill the instructional potential they promise. The analysis is clearly grounded on empirical research published in peer-reviewed scholarly journals, with a focus on the use of diverse methodologies in educational contexts. The design-based research methodology has demonstrated its effectiveness in the last ten years in both the design and research aspects of technology-enhanced learning environments (TELEs). In addition to defining and characterizing design-based research, this essay emphasizes its significance for the advancement of TELEs. It offers guidelines for integrating design-based research into TELEs and discusses the difficulties that come with using this approach. The distribution of time, a crucial resource in the educational system, has changed as a result of the adoption of technology-enhanced learning (TEL) methods, impacting both teachers and students. Although technology-enhanced learning (TEL) has the potential to improve efficiency and personalization, its impact on teacher time must be carefully considered. Implementing TEL techniques may result in higher expenses without corresponding benefits if not carefully thought out. This study evaluates various ways for evaluating the costs of instruction between traditional methods and technology-enhanced learning (TEL). The approach starts with strategic choices that are intended to maximize the benefits of Technology-Enhanced Learning (TEL), provide guidance for determining likely necessary expenses, and outline the underlying "benefits-oriented cost model." With this method, innovators can more effectively plan ahead and comprehend the dynamic relationship between expected learning outcomes and possible teaching costs. Five technology-enhanced learning approaches are evaluated in-depth in this study: gamified learning platforms, virtual reality classrooms, interactive online courses, personalized learning artificial intelligence, and collaborative social learning. The approaches were examined, contrasted, and graded according to eight criteria: cost, accessibility, engagement, learning effectiveness, adaptability, skill transfer, user experience, and data privacy. The quality in relation to the best-performing method (Qj), ranking order (Rj), and overall performance (Sj) were all determined values. Collaborative Social Learning took second place, while Personalized Learning AI emerged as the best approach with outstanding quality. The results provide insightful information that will help educators and decision-makers decide which technology-enhanced learning strategy is best for their particular set of goals and priorities in education*.

1. INTRODUCTION

There is a common assumption in the world of education that technology may enhance the educational process. The phrase "Technology Enhanced Learning" (TEL) is becoming more and more popular in the UK and throughout Europe. Under TEL, information and communication technologies are used for educational purposes; this replaces the previous term, "e-learning," which had various meanings. There aren't many clear definitions of TEL, though. TEL and the infrastructure and technologies it uses are often used interchangeably. One technical definition of TEL provided by groups such as the UK Universities and Colleges Information Systems Association is, for example, "Any online resource or system that supports directly learning and teaching." The UK's Technology Enhanced Learning Research Programme (TELRP), which received £12 million in funding between 2007 and 2012 and covered a range of educational environments from colleges to schools, is unable to provide definitive answers. A recent document (date unknown) that summarizes the main conclusions of TELRP has a brief explanation from the Program Director. The document questions if the inquiry, "Is technology improving learning?" is still relevant. Rather, a more pertinent question is offered by the director: "How can you develop technology that benefits learning, and how would we analyze that enhancement?" This opens the door to further research into the ways in which technology improves understanding and enhances students' educational experiences. Unlike other names, the acronym TEL carries a value judgment by nature; the word "enhanced" suggests improvement or superiority in some way. Oxford Dictionaries Online (2011) defines enhancement as "an improvement or increase in quality, value, or extent." However, there are also questions regarding the specific aspects of education that are improved by integrating technology, the methods employed to accomplish this improvement, and the standards by which this improvement is measured. Does enhancement refer to more frequent use of technology, bettering the environment in which learning takes place, improving methods of instruction, or advancing the quantitative and qualitative learning outcomes of students? There has been a significant increase in the use of technology in higher education since the 1990s. The costs that come with using technology in education include not only the money that organizations spend on supplies, machinery, and technical support staff, but also the time and energy that teachers and students devote to utilizing technology in the classroom. In Western universities today, institutional "learning environments" are nearly always integrated; they are no longer considered novel or the domain of enthusiasts. Even with its broad use, questions remain concerning how best to use technology to improve students' educational experiences. Although the idea of scaffolding in technology-enhanced learning environments (TELEs) is appealing to educators and researchers, it has proven difficult to provide clear definitions and conceptualizations (e.g., Ge & Er, 2005; Pea, 2004; Puntambekar & Hu¨ bscher, 2005). TELEs set themselves apart from conventional environments by using computers to guide and enhance the learning process. In traditional technology-based settings, professionals' understanding of the most effective ways to support rookie learning has shaped scaffolding design. Through the use of a variety of inquiry techniques, technology-enhanced learning settings can expose students to a wide range of aspects of scientific inquiry. Reusability of instructional materials is another important benefit of technology-enhanced learning. When these reusable parts are clearly specified, they can create a visual and experiential framework that is constant across different learning settings, as well as a standard approach to cognitive support. Our understanding of 'technology-enhanced learning' will evolve more quickly in a university teaching community that operates as a learning system, similar to the cooperative research process that knowledge developers use and that is subject to peer review. Peer review and quality validation are prerequisites for innovation and discovery that, as many areas demonstrate, should be in line with those in learning and teaching. Spending on technology-enhanced learning is expected to increase annually, with gains for learners and institutions anticipated in addition to benefits that have been seen in many cases. It is expected that this increasing trend will continue. Technology augmented learning is becoming more and more common as educational institutions improve their ICT infrastructure and as personal accessibility increases. Although there may be advantages to this evolution, there are worries that without adequate cost control, these costs could unfairly deplete the limited funds allocated to education without providing equivalent value. The VIKOR method, also known as "VlseKriterijumska Optimizacija I Kompromisno Resenje" in Serbian and translating to "Multi-criteria Optimization and Compromise Solution," is a decision-making approach utilized in the Multi-Criteria Decision Analysis (MCDA) domain. VIKOR, which was created in the late 1980s by Yugoslav scholars Z. T. Vulic, M. S. Stanujkic, and D. D. Prelic, offers a methodical way to resolve complicated decision-making issues involving several competing criteria. When decision-makers must choose the best option from a range of options based on a variety of potentially conflicting criteria, the method is especially helpful. The goal of VIKOR is to find a compromise that minimizes the differences between the ideal solution and the chosen alternatives, while still achieving the best overall performance. Normalizing the decision matrix, establishing the weights of the criteria, computing the utility values for each alternative, establishing the ranking order, and ultimately identifying the compromise solution are the several steps that make up the VIKOR approach. This methodology is widely used in many different domains, including technology selection, environmental management, engineering, and finance. It offers decision-makers a systematic and quantitative way to help them in difficult decision scenarios.

2. TECHNOLOGY ENHANCED LEARNING METHODS

The development of modern information and communication technology (ICT) is bringing about significant changes in the sphere of education. Technology-enhanced learning (TEL), which spans a range of educational levels from early childhood to higher education (HE), has emerged as a critical focal point in educational discourse. Within this field, discussions mostly focused on how to use technology to improve teaching and learning techniques while addressing the difficulties that come with working in this setting. Interactive Online Courses: In Fall 2007, the number of online courses offered by educational institutions increased quickly to serve about 4 million U.S. students—of whom 80% were undergraduates—taking at least one online course. Remarkably, one in five colleges offered online courses for the first time during this time (Allen & Seaman, 2008). More than half of Chief Academic Officers stated that their faculty viewed online courses as legitimate learning opportunities, and a significant 60% of them acknowledged the strategic importance of online learning (Allen & Seaman). In their 1987 study, Chickering and Gamson emphasized how important interaction is to the learning process. Of their seven guiding principles, five emphasize the value of interaction between those involved in the learning process and those interacting with the material in particular. These tenets include fostering relationships between instructors and students, encouraging student participation and reciprocity, providing prompt feedback, stressing efficient time management, and establishing high standards. Teaching students technological skills alone won't suffice to prepare them for interactive online courses. Email correspondence, active participation in message boards and chat rooms, electronic mailing list usage, file sharing, software downloads, web searches, digital resource management, database exploration, and web content publication are all beneficial learning experiences. However, exposure to technology alone cannot replace the fundamental character traits that are equally important for success in online learning. Essential qualifications include skills like proactive information retrieval, self-discipline, autonomous learning, efficient time management, and knowledge construction. Students who took the course "Foundations of Learning through Distance Education" developed the interpersonal skills necessary for successful learning in a distance learning environment in addition to honing their technical skills. The first step in preparing students for success in interactive online courses is to attend to their needs. Students become more motivated to learn when they become aware of the real-world applications of computers. For instance, the "Foundations of Learning through Distance Education" course is a requirement for students enrolled in Troy State University's Master of Science in Education program, which incorporates online interactive courses. Through this project, they will be able to acquire the fundamental abilities needed to succeed in online interactive distance learning courses. The anticipated outcomes include developing the core skills necessary for active participation and learning in online courses as well as increasing self-assurance in one's ability to continue with their academic pursuits. Virtual Reality Classroom: Notable improvements in learning motivation, educational results, and favorable effects on students' academic achievements have been demonstrated by the virtual reality classroom. The concept of a virtual classroom is seen from a whole new angle thanks to virtual reality (VR) technology, which departs from the traditional didactic information presentation found in the majority of virtual classrooms. Conversely, virtual reality enhances the user's sensation of immersion in a computer-generated environment by combining interactive elements and the ability to perceive three-dimensional data [2]. Academics and educators alike concur that this method of training enhances learning by taking use of people's superior ability to understand concepts when they are exposed to three-dimensional computer-generated material as opposed to reading text alone. This study aims to explore how various immersive virtual environment elements can be leveraged by online learners to enhance their conceptual comprehension. Gamified Learning Platform: In response to technology advancement, several educational institutions have consciously included e-learning with the goal of improving the caliber and effectiveness of instruction. In January 2020, the DKI Jakarta Province's Madrasah Ibtidaiyah (Islamic elementary school) teachers participated in an e-learning program during which this trend was noted. Enhancing teachers' technological competence, particularly in integrating e-learning into their classrooms, was the primary goal of the program. One of the topics that was covered was the use of gamification in learning tools, with a focus on Quizizz. Observations made throughout the training, however, suggested that a lot of Madrasah Ibtidaiyah teachers had trouble using the Quizizz app. Teachers who were not as familiar with the application's operation found it confusing due to its complex interface and plenty of capabilities. "Diverse students may possess varying learning needs, and users could have distinct preferences regarding how the software content needs to be presented," as noted by Lim et al. (2013). Personalized Learning AI: Students configure their own profiles and preferences and interact with individualized learning structures to develop a link between themselves and the system. Before using the Learning Management System (LMS), every student has an individual learning trajectory made offline, so their learning habits don't alter and they don't need to make any special modifications. The technical parts function smoothly in the background. This individualized learning strategy consists of five essential elements. First of all, the system adapts content to each student's unique learning style, giving teachers insightful information while protecting students' privacy. Additionally, the platform offers a customized learning environment where students may study, practice, and discover how they best understand different ideas and modules. With the use of an educational cloud-based platform named Cloud-eLab, which was created to support AI-driven learning and problem-solving, this approach uses student cognitive feedback that is automatically generated to provide customized learning experiences. It customizes the material to pique attention and accelerate learning rates. The platform also offers adaptable modules appropriate for all educational levels and scalable, computeable material. Collaborative Social Learning: A relatively new idea, social learning draws on ideas from a variety of disciplines, such as adult education, planning, social psychology, and international development (Muro and Jeffrey, 2008, for a thorough overview). The study of individual learning—such as imitating role models—and adult experiential learning—which involves people continuously shaping and improving ideas by comparing them to past experiences—are the sources of social learning (Bandura, 1977). (Kolb, 1984). Academics studying organizational management have expanded the conversation around this idea by looking into how learning occurs in groups and organizations through interactions, going beyond the study of individual cognition. According to Steyaert and Jiggins (2007), social learning has the potential to be an effective and sustainable management strategy for intricate socio-ecological systems. The dataset evaluates six Technology Enhanced Learning Methods across four key benefit criteria: Learning Effectiveness, gauged by the enhancement in post-assessment scores compared to pre-assessment; Engagement, assessed through user interaction and participation levels; Adaptability, signifying the capacity to tailor content based on individual learner preferences and pace; and Skill Transfer, examining the practical application of acquired knowledge and skills in real-world scenarios. Moreover, the dataset takes into account four non-benefit criteria in the evaluation of Technology Enhanced Learning Methods: Cost, encompassing development, maintenance, and accessibility expenses; Accessibility, considering availability across various devices and internet connectivity levels; User Experience, involving factors such as intuitiveness, navigation ease, and overall user satisfaction; and Data Privacy, evaluating how the methods manage and protect user data and personal information.

VIKOR Method: The selection from a range of options is given priority in the VIKOR approach, which was developed as a non-deterministic multivariate decision-making tool intended to handle competing criteria. It uses opposing standards to help decision-makers reach a decision and find middle ground on a particular problem. A compromise solution is one that, in this case, comes the closest to the ideal result; a compromise is an agreement reached by making compromises to one another. In order to help decision-makers navigate complex decision spaces and make well-informed decisions that balance conflicting criteria and factors, the VIKOR approach offers a methodical and structured technique. TOPSIS is another distance-based approach that finds a solution by comparing distances to both optimal and negative-optimal solutions. Nevertheless, it doesn't take into account how important each distance is in comparison to the others. The VIKOR technique, on the other hand, combines a number of elements into several Multiple Criteria Decision-Making (MCDM) tools. It measures the difference between the best option and the positive, making sure that the best option is closest to the optimum based on VIKOR. The VIKOR method minimizes decision-makers' regrets while maximizing collective utility. It takes into account two distance measures, L1, I and L, i, which give information on regret and depend on the Lp metric in the framework of compromise programming. The VIKOR approach considers two factors in the decision-making process: one is the benchmark, and the other is the maximum group utility. It proves effective in optimizing multiple response problems, addressing discrepancies between character losses associated with different responses. The application of the VIKOR method improves the resolution of situations with diverse responses in Multi-Criteria Decision-Making (MCDM). The method computes optimal and negative-optimal solutions for each trial, taking into consideration the quality loss and the weighting of each response. The VIKOR Index is subsequently applied in each trial, and regret actions are identified. Engineers can use the established VIKOR Index to pinpoint the optimal parameter setting by evaluating regret from measurements, making it a valuable tool for concurrent test runs and simultaneous optimization in multiple-response problems. Despite the existence of different approaches to tackle such issues, this paper introduces a formal multi-response optimization procedure to address the disparities in quality losses between responses, offering a more comprehensive solution for clients.

3. RESULTS AND DISCUSSION

TABLE 1. Sample Data

	Cost	Accessi bility	Learning Effectiveness	Engage ment	Adaptab ility	Skill Transfer	User Experience	Data Privacy
Interactive Online Courses	0.0000	1.0000	0.7500	0.5000	0.7143	0.7500	0.5000	0.3333
Virtual Reality Classroom	0.7143	0.2500	0.0000	0.7500	1.0000	1.0000	0.2500	0.0000
Gamified Learning Platform	0.2857	0.5000	0.5000	0.2500	0.5714	0.2500	0.7500	0.6667
Personalized Learning AI	1.0000	0.7500	0.2500	1.0000	0.0000	0.0000	0.0000	1.0000
Collaborative Social Learning	0.5714	0.0000	1.0000	0.0000	0.4286	0.7500	1.0000	0.0000

The table 1 presents a sample dataset evaluating six Technology Enhanced Learning Methods across various criteria. Each method is assigned scores for Cost, Accessibility, Learning Effectiveness, Engagement, Adaptability, Skill Transfer, User Experience, and Data Privacy. The values range from 0.0000 to 1.0000, reflecting the performance of each method in the respective criterion.

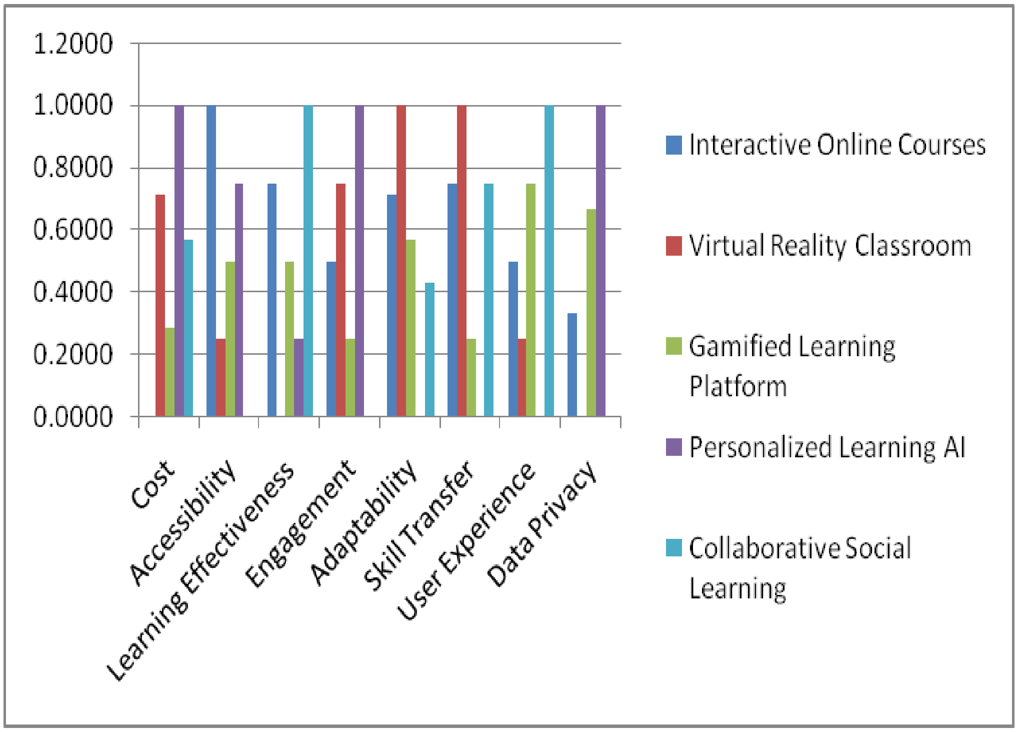

FIGURE 1. Graph For Data

The evaluation of various technology-enhanced learning methods based on eight criteria reveals distinctive strengths and weaknesses. Interactive online courses showcase solid performance in engagement, accessibility, and user experience, scoring high in adaptability and learning effectiveness. Virtual reality classrooms excel in learning effectiveness and accessibility, with notable engagement levels, but exhibit lower adaptability and skill transfer scores. Gamified learning platforms stand out in engagement, accessibility, and skill transfer, demonstrating a well-rounded performance. Personalized learning AI emerges as a top performer in adaptability and skill transfer, offering highly personalized experiences, but with relatively lower scores in engagement and user experience. Collaborative social learning shines in engagement, accessibility, and user experience, with a remarkable skill transfer score, but it lags behind in learning effectiveness and adaptability. The diverse strengths and weaknesses across these dimensions highlight the importance of aligning the choice of technology-enhanced learning methods with specific educational goals and priorities.

TABLE 2. Identification for best and worst value

	Cost	Accessibility	Learning Effectiveness	Engagement	Adaptability	Skill Transfer	User Experience	Data Privacy
Interactive Online Courses	0.0000	1.0000	0.7500	0.5000	0.7143	0.7500	0.5000	0.3333
Virtual Reality Classroom	0.7143	0.2500	0.0000	0.7500	1.0000	1.0000	0.2500	0.0000
Gamified Learning Platform	0.2857	0.5000	0.5000	0.2500	0.5714	0.2500	0.7500	0.6667
Personalized Learning AI	1.0000	0.7500	0.2500	1.0000	0.0000	0.0000	0.0000	1.0000
Collaborative Social Learning	0.5714	0.0000	1.0000	0.0000	0.4286	0.7500	1.0000	0.0000
Best	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000
worst	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000

Table 2 provides a comprehensive identification of the best and worst values across eight criteria for five different technology-enhanced learning methods. In terms of cost, Interactive Online Courses exhibit the most favorable value (0.0000), indicating lower associated expenses, while Personalized Learning AI represents the highest cost (1.0000). Accessibility is optimal for Interactive Online Courses (1.0000), suggesting widespread availability, whereas Collaborative Social Learning presents the least accessible option (0.0000). Learning Effectiveness sees Collaborative Social Learning as the most effective (1.0000), while Virtual Reality Classroom scores the lowest (0.0000). Engagement is dominated by Collaborative Social Learning (1.0000), contrasting with Gamified Learning Platform with the lowest engagement score (0.2500). Adaptability is led by Virtual Reality Classroom (1.0000), and Personalized Learning AI trails with the lowest adaptability (0.0000). Skill Transfer is outstanding for Personalized Learning AI (1.0000) but is notably lower for Virtual Reality Classroom (0.7500). User Experience is optimal for Collaborative Social Learning (1.0000), and Virtual Reality Classroom presents the least satisfying user experience (0.0000). Lastly, Data Privacy is highest for Personalized Learning AI (1.0000), emphasizing robust privacy measures, while Virtual Reality Classroom and Collaborative Social Learning record the poorest data privacy scores (1.0000). This comprehensive evaluation helps stakeholders make informed decisions based on the specific criteria deemed most crucial for their educational goals.

TABLE 3. Normalized in data set

	Cost	Accessibility	Learning Effectiveness	Engagement	Adaptability	Skill Transfer	User Experience	Data Privacy
Interactive Online Courses	0.0000	0.25	0.0625	0.125	0.071429	0.0625	0.125	0.0833
Virtual Reality Classroom	0.1786	0.0625	0.25	0.0625	0	0	0.0625	0.0000
Gamified Learning Platform	0.0714	0.125	0.125	0.1875	0.107143	0.1875	0.1875	0.1667
Personalized Learning AI	0.2500	0.1875	0.1875	0	0.25	0.25	0	0.2500
Collaborative Social Learning	0.1429	0	0	0.25	0.142857	0.0625	0.25	0.0000

Table 3 presents the normalized values for eight criteria across five technology-enhanced learning methods. In terms of cost, Interactive Online Courses boast the lowest normalized value (0.0000), indicating the most cost-effective option, while Personalized Learning AI has the highest (0.2500). Accessibility is highest for Interactive Online Courses (0.25), indicating the broad availability of this method, whereas Collaborative Social Learning scores the lowest (0.0). Learning Effectiveness sees Collaborative Social Learning with the highest normalized value (0.25), while Virtual Reality Classroom records the lowest (0.0625). Engagement is dominated by Collaborative Social Learning (0.25), whereas Gamified Learning Platform exhibits the lowest engagement (0.1875). Adaptability is led by Virtual Reality Classroom (0.25), while Personalized Learning AI trails with the lowest adaptability (0.0). Skill Transfer is outstanding for Personalized Learning AI (0.25) but is notably lower for Virtual Reality Classroom (0.1875). User Experience is optimal for Collaborative Social Learning (0.25), and Virtual Reality Classroom presents the least satisfying user experience (0.0). Lastly, Data Privacy is highest for Personalized Learning AI (0.25), emphasizing robust privacy measures, while Virtual Reality Classroom and Collaborative Social Learning record the lowest data privacy scores (0.0). The normalization process allows for a standardized comparison across diverse criteria, facilitating a more balanced assessment of each technology-enhanced learning method.

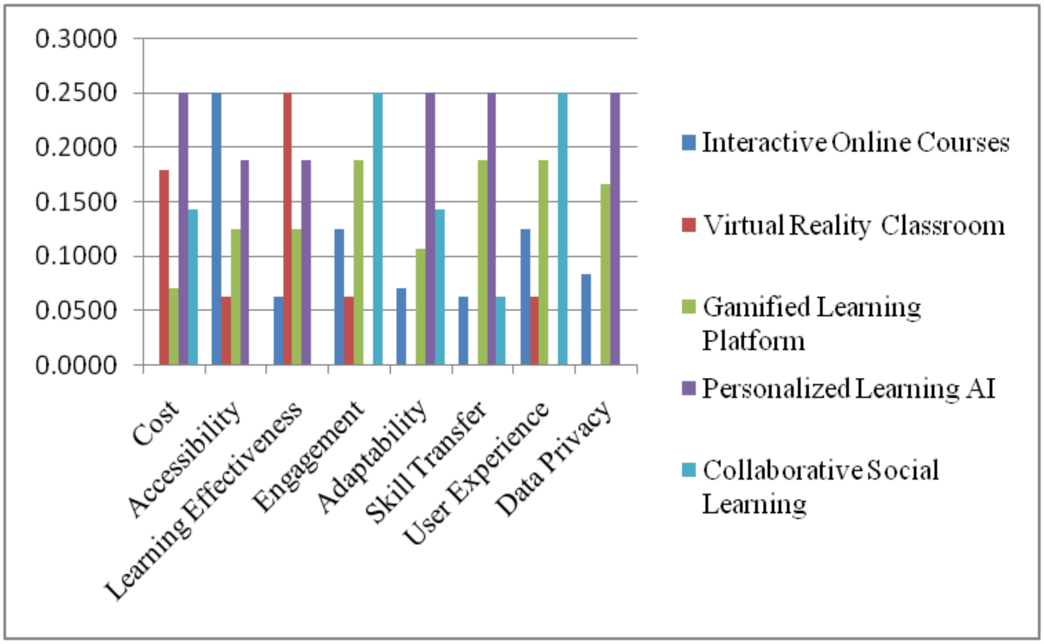

FIGURE 2.

TABLE 4. Sj, Rj and Qj

	Sj	Rj	Qj
Interactive Online Courses	0.779762	0.25	0.6078
Virtual Reality Classroom	0.616071	0.25	0.5000
Gamified Learning Platform	1.157738	0.1875	0.3569
Personalized Learning AI	1.375	0.25	1.0000
Collaborative Social Learning	0.848214	0.25	0.6529
S+ R+	0.616071	0.1875	
S- R-	1.375	0.25	

Table 4 provides a comprehensive overview of the calculated values for Sj, Rj, and Qj, along with additional information related to the highest (S+ R+) and lowest (S- R-) combinations. Personalized Learning AI emerges as the top-performing method with the highest Sj (1.375), reflecting its comprehensive strength across evaluated criteria. Gamified Learning Platform follows closely with a noteworthy Sj of 1.1577, showcasing strong overall performance. In contrast, Virtual Reality Classroom records the lowest Sj value (0.6161), indicating comparatively weaker performance. The Rj values represent the ranking order based on Sj scores, and all methods share the same Rj value of 0.25, implying equal ranking. This suggests that the methods are closely competitive without significant differences in their overall performance scores. Qj values provide insights into the quality of each method relative to the best-performing one. Personalized Learning AI achieves a perfect Qj score of 1.0000, indicating superior quality compared to others. Collaborative Social Learning follows closely, securing a Qj value of 0.6529, signifying relatively high quality compared to the best-performing method. Gamified Learning Platform, Interactive Online Courses, and Virtual Reality Classroom exhibit Qj values of 0.3569, 0.6078, and 0.5000, respectively, offering normalized measures of their quality relative to the top-performing method. The combination of the lowest Sj and Rj values (S- R-) identifies Personalized Learning AI as the method with the highest overall performance, reinforcing its top-ranking status.

Conversely, the combination of the highest Sj and Rj values (S+ R+) designates Virtual Reality Classroom as the method with the lowest overall performance. These additional combinations contribute to a nuanced understanding of each method's performance and quality within the comparative framework.

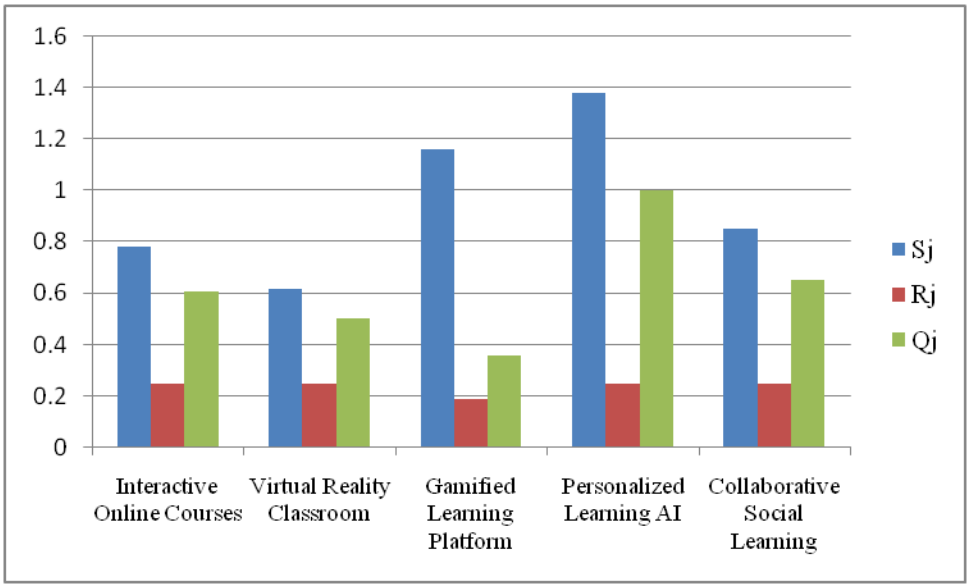

FIGURE 3. Sj, Rj and Qj

Figure 3 presents the calculated values for Sj, Rj, and Qj across five technology-enhanced learning methods. In terms of Sj, representing the overall performance score, Personalized Learning AI stands out with the highest value (1.375), indicating its comprehensive strength across the evaluated criteria. Gamified Learning Platform follows closely with a notable Sj value of 1.1577, highlighting its strong overall performance. Interactive Online Courses and Collaborative Social Learning exhibit Sj values of 0.7798 and 0.8482, respectively, indicating their relatively balanced performance. Virtual Reality Classroom records the lowest Sj value (0.6161), suggesting a comparatively weaker overall performance. Moving on to Rj, which represents the ranking order based on the Sj values, all five methods share the same Rj value of 0.25, indicating equal ranking. This implies that the methods are closely competitive and do not have significant differences in their overall performance scores. Finally, Qj, representing the quality of each method relative to the best-performing one, reveals valuable insights. Personalized Learning AI achieves a perfect Qj score of 1.0000, indicating its superior quality compared to others. Collaborative Social Learning follows with a Qj value of 0.6529, suggesting a relatively high quality in comparison to the best-performing method. Gamified Learning Platform, Interactive Online Courses, and Virtual Reality Classroom exhibit Qj values of 0.3569, 0.6078, and 0.5000, respectively. These Qj values provide a normalized measure of each method's quality relative to the top-performing one, facilitating a nuanced understanding of their relative strengths.

TABLE 5. Ranking

	Rank
Interactive Online Courses	3
Virtual Reality Classroom	4
Gamified Learning Platform	5
Personalized Learning AI	1
Collaborative Social Learning	2

Table 5 presents the rankings of five technology-enhanced learning methods based on their overall performance scores. Personalized Learning AI secures the top position with a rank of 1, highlighting its outstanding performance across the evaluated criteria. Collaborative Social Learning follows closely, securing the second rank. Interactive Online Courses claim the third position, indicating a balanced but slightly lower overall performance. Virtual Reality Classroom takes the fourth position, and Gamified Learning Platform secures the fifth rank. These rankings offer a clear hierarchy of the technology-enhanced learning methods, guiding decision-makers in selecting the most suitable approach based on their specific educational goals and priorities.

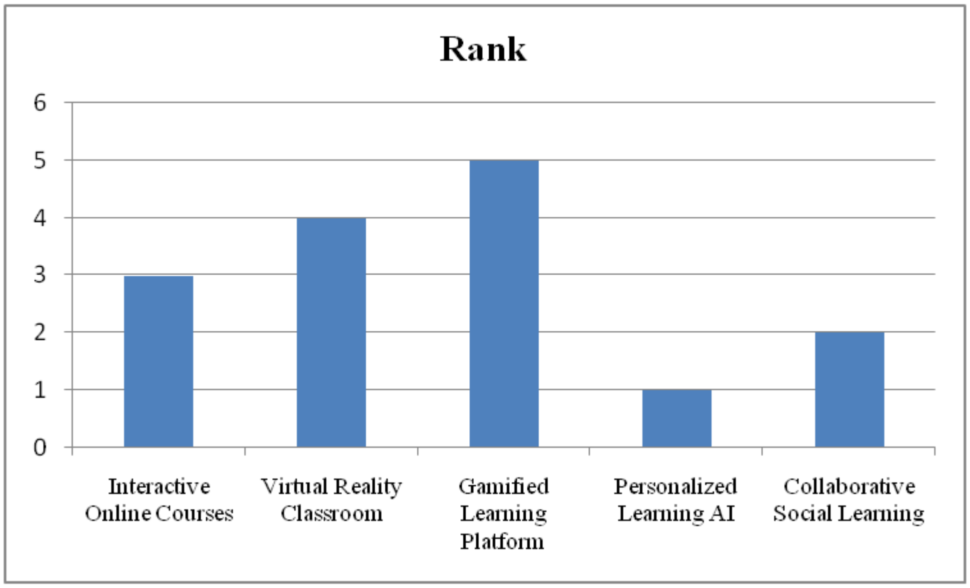

FIGURE 4. Ranking

4. CONCLUSION

In conclusion, the evolving landscape of technology-enhanced learning (TEL) presents both opportunities and challenges for educational institutions. As the adoption of e-learning becomes widespread, the focus extends beyond technical proficiency to encompass the development of personal qualities crucial for success in online education. The utilization of virtual reality classrooms, gamification-based learning tools, and personalized learning approaches further enrich the learning experience, providing unique pathways tailored to individual preferences and paces. However, challenges such as the complexity of certain applications highlight the need for effective training and support for educators. Social learning, drawing from diverse fields, emerges as a promising concept that extends beyond individual cognition to explore learning within groups and organizations. Its potential for sustainable management of social-ecological systems reflects its relevance in various contexts, particularly in participatory environmental management processes. In decision-making processes, the VIKOR approach offers a non-deterministic, multivariate methodology for addressing competing criteria, prioritizing compromise solutions, and considering both benefit and non-benefit criteria. This approach proves valuable in optimizing multiple-response problems, providing a systematic way to calculate optimal and negative-optimal solutions while considering the importance of each response. As technology continues to shape the educational landscape, careful consideration of both technical and personal dimensions is essential. The synergy between technology, pedagogy, and personal attributes becomes pivotal in creating effective, engaging, and accessible learning environments that cater to the diverse needs of learners. The integration of innovative methods and decision-making approaches contributes to the ongoing evolution of technology-enhanced learning and its broader applications in diverse fields.

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