

Enhancing online learning quality: a structural equation modeling analysis of educational technology implementation during the COVID-19 pandemic

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ABSTRACT

This study investigates the execution of online education at the Faculty of Tarbiyah and Teacher Training in Islamic State Universities in Indonesia during the COVID-19 pandemic. It assesses the platform's efficacy and quality, particularly regarding system, information, and service excellence. The study employs descriptive statistical analysis and structural equation modeling to discern strengths and weaknesses in the online learning environment, emphasizing system dependability and user satisfaction. It underscores the necessity for improvements in delivering timely information and enhancing responsiveness to fulfill consumer expectations better. The results highlight the necessity of strategic improvements emphasizing adaptability and service quality to enhance the online learning experience. These developments are especially vital in emergencies, where the adaptability and resilience of instructional technologies are evaluated. This study provides actionable recommendations for educational institutions to enhance the quality, resilience, and effectiveness of online learning for both students and educators, offering essential insights to address current challenges and contribute to the broader discourse on the future of online education.

1. Introduction

The education landscape underwent a profound transformation with the onset of the COVID-19 pandemic, prompting educational institutions worldwide to adapt to remote learning modalities swiftly [1–4]. Among these adaptations, online learning emerged as a cornerstone for ensuring the continuity of education. Within the context of Islamic State University across Indonesia, the Tarbiyah & Teaching Science Faculty navigated this transition, implementing online learning systems to sustain academic activities during challenging times. A comprehensive analysis of the effectiveness and quality of these online learning systems became imperative to gauge their impact on student outcomes amidst the pandemic's disruptions [5–11].

The research conducted at Tarbiyah & Teaching Science Faculty delves into the nuanced aspects of online learning implementation during COVID-19, offering valuable insights into its efficacy and quality. The study scrutinizes various dimensions such as system quality, information quality, service quality, and user satisfaction through meticulous examination [12–15]. By dissecting these components, the research aims to uncover the strengths and areas for improvement within the online learning system, providing actionable insights for institutional

stakeholders to refine and enhance the educational experience [16–18].

One of the focal points of the analysis revolves around system quality, encompassing factors like usability, adaptability, speed, and reliability. While the study acknowledges the satisfactory overall quality of the online learning system, it also identifies specific areas ripe for enhancement [19,20]. Notably, attention is drawn towards ensuring the currency of content and bolstering security measures to fortify the system's resilience and user trust [21–23]. These findings underscore the necessity for continuous refinement and updates to meet users' evolving needs and expectations, especially during times of crisis [24–26].

Implementing online learning at Tarbiyah & Teaching Science Faculty in Islamic State University across Indonesia during the COVID-19 pandemic has sparked significant interest and scrutiny. This period of unprecedented change has necessitated a thorough examination of the effectiveness and quality of the online learning system [27–30]. To address this need, the research embarks on a comprehensive analysis to uncover insights into various dimensions of online learning delivery. Central to this inquiry are several key research questions that guide the investigation and shed light on the intricacies of online education in challenging times.

This study seeks to assess the efficacy of the online learning platform

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established at the Tarbiyah & Teaching Science Faculty in Islamic State Universities throughout Indonesia amidst the COVID-19 epidemic. The objective is to pinpoint the system's strengths and areas that need improvement, explicitly focusing on system quality, information quality, and service quality. In addition, the research seeks to analyze the influence of the online learning system on student outcomes, encompassing satisfaction levels and academic achievement. This study aims to improve the quality and effectiveness of online education, particularly in challenging situations such as the COVID-19 epidemic, by offering recommendations based on research findings.

The novelty of this research stems from its holistic approach to assessing the online learning system in Islamic higher education institutions in Indonesia during the pandemic. This research differs from past studies in that it examines service quality as a crucial determinant of customer pleasure and engagement rather than focusing on technological concerns. This study provides a comprehensive and integrated viewpoint by combining studies of system quality, information quality, and service quality. This approach has yet to be widely investigated in previous research. This methodology allows the researchers to determine the correlation between the quality of services and students' achievements, offering fresh perspectives on how online education can be enhanced within the framework of Islamic higher education. Therefore, this study provides a noteworthy and unique contribution to online education, specifically in times of crisis like the pandemic. It also serves as a crucial point of reference for educational institutions striving to improve online learning consistently.

Expanding upon the extensive framework, the proposed study will thoroughly evaluate the online learning system implemented by the Tarbiyah & Teaching Science Faculty at Islamic State Universities throughout Indonesia during the COVID-19 pandemic. The goal is to comprehensively assess the system's effectiveness by examining crucial criteria such as its quality, the information it delivers, and the services it provides. Furthermore, the study will examine the broader impact of these factors on student results, with a specific emphasis on satisfaction and academic performance. This research endeavors to provide practical recommendations for enhancing online education's overall quality and efficacy by assessing the current system's strengths and shortcomings. The findings obtained from this study are anticipated to guide the continuous improvement of online learning approaches, maintaining their efficacy in meeting the changing educational requirements, especially during crises such as the COVID-19 epidemic.

2. Literature review

The COVID-19 pandemic has brought about a rapid and widespread shift towards online learning, highlighting the importance of understanding the factors influencing its quality. This study investigates the impact of educational technology implementation on online learning quality during the pandemic. By utilizing structural equation modeling (SEM), the study seeks to identify the critical determinants of online learning quality and their interrelationships [31,32].

Previous research has emphasized the significance of system, information, and service quality in enhancing online learning effectiveness [33]. System quality, encompassing accessibility, reliability, and scalability, ensures a positive user experience. Similarly, information quality, which includes content relevance, accuracy, and timeliness, has been identified as a critical determinant of learning outcomes. Service quality, including technical support and communication channels, has also been shown to impact student engagement and satisfaction.

Methodologically, this study adopts a quantitative research design, collecting data from students and instructors who participated in online learning during the COVID-19 pandemic. A structured questionnaire assesses perceptions of online learning quality, educational technology implementation, and other relevant variables. The data is then analyzed using structural equation modeling to examine the relationships between these variables and their impact on online learning quality [34].

Preliminary results suggest that educational technology implementation significantly influences online learning quality, with system quality, information quality, and service quality mediating roles in this relationship. Improvements in system quality, such as enhanced accessibility and reliability, are associated with higher perceived online learning quality. Similarly, higher levels of information quality, including relevant and accurate content, contribute to better learning outcomes. Effective service delivery, including responsive technical support and communication channels, positively impacts student satisfaction and engagement [35].

This study highlights the critical role of educational technology implementation in enhancing online learning quality during the COVID-19 pandemic. By improving system, information, and service quality, educational institutions can optimize the online learning experience for students and instructors. These findings have implications for the future of online education, emphasizing the importance of continuous improvement and innovation in educational technology.

The literature review explores various aspects of online learning quality, shedding light on key factors contributing to a successful online learning experience. System quality, encompassing online learning platforms' technical infrastructure and usability, is crucial in ensuring reliability, accessibility, and scalability. For instance, user-friendly interfaces and stable platforms facilitate smooth interactions and engagement. Information quality is another critical aspect, emphasizing educational content's relevance, accuracy, and credibility. This aspect directly impacts learning outcomes, highlighting the importance of well-curated and up-to-date materials. Moreover, service quality, including support services and communication channels, significantly influences student engagement and satisfaction. Adequate technical support and communication channels enhance the learning experience, providing students with the assistance they need to succeed.

Flexibility is a crucial feature of online learning, allowing personalized learning experiences tailored to different learning styles and schedules. Adaptability is particularly valuable in accommodating diverse student needs and preferences. Interactivity further enhances the learning process by fostering engagement and knowledge retention. Platforms that facilitate interactions between students, instructors, and course content through features like discussion forums and virtual labs can significantly improve the learning experience. Additionally, feedback mechanisms are essential for providing students with timely and constructive feedback on their performance. Automated quizzes and peer assessment tools are examples of mechanisms that can help students track their progress and improve their learning outcomes.

Content relevance is paramount in online learning, ensuring educational content aligns with learning objectives and real-world applications. This alignment enhances the relevance of learning materials, making them more engaging and meaningful for students. Accessibility is also crucial, ensuring that online learning resources and platforms are easily accessible to all students. Features like mobile compatibility and screen reader support are essential for ensuring inclusivity and reach. Lastly, multimedia integration, incorporating various media formats such as videos and simulations into learning materials, enhances engagement and understanding. Integrating multimedia elements into online courses can make learning more interactive and practical, catering to diverse learning preferences.

2.1. System quality

Prior studies have continuously emphasized the importance of system quality in online learning settings, highlighting its central role in establishing a favorable user experience. System quality encompasses the technical elements of an online learning platform, such as accessibility, reliability, and scalability. These factors are crucial for ensuring a smooth and efficient learning experience. Accessibility guarantees that all users can easily access the platform and its resources, irrespective of their location, device, or internet speed. Reliability ensures the seamless

operation of the system, minimizing frequent interruptions and enabling learners to concentrate on their studies without being distracted by technical issues. Scalability guarantees that the system can effectively manage fluctuating user numbers and adjust to the increasing demands of the institution without sacrificing performance [46,47]. These components collectively constitute the foundation of a resilient online learning system, directly shaping how students and instructors engage with the platform.

Accessibility is a fundamental aspect of system quality that defines how students can effectively interact with the online learning environment. Within the global educational context, students can utilize online platforms from diverse geographical areas, each with varying internet connectivity and device capabilities. An optimal system should address these disparities, guaranteeing that every student has equitable access to online educational endeavors. This encompasses enhancing the platform to be compatible with mobile devices, ensuring that content loads rapidly even on slower connections, and incorporating features to cater to users with impairments. Prioritizing accessibility eliminates learning obstacles, fostering a more inclusive and fairer educational environment for all students [48,49].

Reliability is a crucial aspect of system quality, as it ensures the continuous and uninterrupted operation of the online learning platform. A dependable system mitigates technological problems like server failures, sluggish loading speeds, and unanticipated periods of inactivity, which can interrupt the learning process and exasperate users. When students encounter frequent technological issues, their attention diverts from learning to resolving problems, reducing enthusiasm and involvement. In contrast, a dependable system offers a consistent setting in which students can have confidence that their educational tasks will progress seamlessly, enabling them to focus on their studies without concern for possible technical malfunctions. The dependability of a system is especially crucial in critical scenarios, such as during examinations or when meeting submission deadlines, as any interruption might result in substantial repercussions [50,51].

Ensuring scalability is crucial for sustaining the quality of a system, particularly when faced with expanding student populations and a rising demand for online education. A scalable system can effectively handle a substantial number of concurrent users while maintaining optimal performance, guaranteeing a seamless and prompt experience for all students, irrespective of the platform's current user load. This is especially vital at times of high usage, such as the beginning of a new semester or during exam periods, when online platforms may encounter a significant increase in activity. A scalable system enables educational institutions to increase their online offerings, supporting more students and courses without requiring a total infrastructure reconstruction. Adaptability is crucial for ensuring online learning programs' long-term viability and expansion.

The efficiency of the educational experience delivered by an online learning system is directly influenced by its robustness, which is decided by its accessibility, reliability, and scalability. A resilient system offers a consistent and foreseeable setting where students can actively participate in course materials, communicate with classmates and teachers, and fulfill evaluations without facing technological obstacles. The reliability of the online learning platform is essential for establishing trust, as students are more inclined to fully participate in their studies when they have confidence in the system's regular assistance. Moreover, a robust system improves the learning experience by facilitating the smooth integration of multimedia resources, interactive tools, and collaborative activities, increasing the educational experience by making it more engaging and effective.

Additionally, the system's quality is intricately connected to user pleasure, which is pivotal in the triumph of online learning programs. When students have favorable encounters with the online learning platform, marked by convenient accessibility, reliable functionality, and the capacity to accommodate many users, they are more inclined to maintain their motivation and dedication to their studies. Increased user

satisfaction correlates with improved retention rates since students are less inclined to withdraw from courses due to technological difficulties. Moreover, contented users are inclined to offer favorable feedback and endorsements, thus bolstering the institution's standing and enticing more students to enroll in its online programs. Hence, allocating resources to enhance system quality entails enhancing the technological infrastructure and cultivating a conducive and inspiring learning environment, thereby fostering a sense of motivation and commitment among the audience.

The significance of system quality in online learning environments cannot be exaggerated, as it serves as the fundamental basis for all other elements of the learning experience. An accessible, reliable, and scalable system caters to the varied requirements of students and educators, enabling them to concentrate on teaching and learning instead of grappling with technological obstacles. As the field of online education expands and develops, it will be crucial to prioritize the maintenance of excellent system quality to uphold the effectiveness and attractiveness of these programs. Educational institutions must prioritize the establishment and upkeep of resilient online learning systems, acknowledging that these investments are vital for the achievement of students and the institution's overall success.

Technological progress poses both difficulties and prospects for upholding system excellence in online learning settings. Institutions must regularly evaluate and enhance their systems to suit the changing requirements of their users as new tools and platforms become available. To effectively manage the system, it is necessary to take a proactive strategy, which involves regularly updating it, integrating user feedback, and implementing the best practices in digital education. To guarantee that their online learning systems are robust, easy to use, dependable, and capable of handling increased demand, schools should stay updated on technical advancements.

2.2. Information quality

The quality of information is a fundamental aspect of online learning, directly impacting the effectiveness and efficiency of the educational process. It includes various crucial elements, such as the significance, precision, and promptness of the content provided via online platforms. Relevance guarantees that the content is in line with the learning objectives and fulfills the requirements of the students, equipping them with the desired information and skills. Precision is crucial in upholding the legitimacy of instructional content, guaranteeing that students acquire accurate and dependable information. Timeliness, however, requires ensuring the content is regularly updated with the most recent advancements and research, which is essential in a quickly changing environment. Educators and instructional designers play a crucial role in ensuring these elements of information quality, thereby establishing the basis for a solid and practical online learning experience.

Relevance in online learning content refers to the need for the material to directly connect to the student's academic objectives and practical use in real-life situations. Students may feel disengaged and less motivated to learn when the content is irrelevant. Relevant information captivates students by connecting academic principles and practical examples they can easily understand and implement in their future professions. This connection improves understanding and inspires students to explore the subject more deeply. For example, in a business management course, using case studies based on current industry practices enhances the learning experience by making it more practical. It equips students with the skills to tackle real-world difficulties. Hence, it is crucial to maintain the pertinence of the content to sustain students' engagement and commitment to their educational progress.

Precision in instructional content is vital, as it forms the foundation of students' trust in their educational institutions. Incorrect or obsolete information can result in misunderstandings, misconceptions, and the spread of erroneous knowledge, which can have significant

consequences in professional and academic environments. In industries such as healthcare or engineering, the accuracy of information is of utmost importance, as even slight inaccuracies can lead to substantial repercussions. Consequently, institutions must thoroughly evaluate their content to guarantee its accuracy and currency, thereby safeguarding the integrity of the educational process and the trust of the learners. This sense of security in the accuracy and currency of the information is crucial for students' peace of mind and confidence in their learning journey.

Punctuality is another crucial feature of the quality of information, especially in sectors where knowledge and practices change frequently. Given the rapid pace of advancements and discoveries today, it is crucial for educational content to represent the latest and most up-to-date knowledge accurately. Consequently, it is imperative to conduct regular evaluations and revisions of online courses to integrate the most recent study discoveries, technology progressions, and modifications in industry benchmarks. By doing this, educational institutions guarantee that their students are not only acquiring up-to-date knowledge but are also equipped to adjust to future developments in their respective professions. This strategy improves the learning experience and guarantees that students maintain competitiveness in the job market.

Ensuring optimal information quality in online learning also requires efficient content curation. Curating content entails carefully selecting the most pertinent, precise, and current organized and readily available resources. This technique is crucial in online learning, as students frequently depend on digital resources without the direct supervision of a teacher. Thoughtfully selected content assists students in navigating extensive quantities of information, prioritizing what is crucial and applicable to their educational goals. This curation facilitates comprehension and optimizes efficiency, enabling students to concentrate on acquiring knowledge rather than engaging in information retrieval [39].

The quality of material offered in online learning systems substantially impacts student results. When students can access pertinent, precise, and up-to-date content, they are more inclined to accomplish their educational goals and effectively apply their acquired knowledge in real-life situations. This practical application of knowledge promotes a favorable learning atmosphere and instills a sense of accomplishment in students. High information quality promotes a favorable learning atmosphere, where students feel assured in the knowledge they gain and are inspired to participate actively in the content. Consequently, this results in increased satisfaction and academic achievement, emphasizing the significance of upholding stringent criteria for material quality in online education.

2.3. Service quality

The effectiveness of online learning environments heavily depends on the quality of service, as it directly impacts student engagement and happiness. Technical support and communication channels are essential components of service quality. They are crucial in successfully enabling students to utilize and gain advantages from the online learning platform. If these services are prompt and dependable, students are more inclined to stay committed to their studies, feel assisted in their learning process, and have a favorable overall experience. This highlights the significance of prioritizing service quality when designing and implementing online learning systems [52,11].

Efficient technical assistance is essential for ensuring seamless and uninterrupted learning experiences. Technical challenges in an online learning environment are unavoidable, encompassing minor malfunctions and more substantial system breakdowns. The presence of fast and expert technical help can be crucial for students facing these challenges since it can determine whether they experience a short setback or a more extended disruption to their learning. Efficient technical assistance promptly resolves issues and empowers students by facilitating their comprehension and preventing similar problems. This type of assistance promotes safety and dependability in the educational platform, essential

for sustaining student assurance and involvement.

The communication channels within online learning platforms are crucial for ensuring student satisfaction. These channels enable communication between students and instructors, as well as among students, fostering a more collaborative and interconnected learning environment. Effective communication, characterized by clarity, timeliness, and accessibility, fosters a sense of community and support among learners, thereby boosting their motivation and participation. On the other hand, insufficient communication might result in emotions of seclusion, annoyance, and disconnection. Hence, it is crucial to ensure that communication channels are seamlessly linked and efficiently handled in order to achieve success in online learning programs [53,54].

Moreover, the caliber of service rendered via technical assistance and communication channels directly impacts students' impressions of the overall learning experience. A positive correlation exists between providing high-quality service and increasing student satisfaction, which can result in enhanced academic achievements. When students perceive that their issues are acknowledged and resolved and receive assistance in their educational pursuits, they are more inclined to remain actively involved, successfully finish their courses, and attain their academic objectives. This emphasizes the correlation between the quality of service and the achievement of educational goals, making it a crucial area of concentration for online learning institutions.

The quality of service, namely the effectiveness of technical assistance and communication channels, is crucial in determining student engagement and satisfaction in online learning environments. By guaranteeing these services' responsiveness, dependability, and availability, educational institutions can cultivate a more supportive and captivating learning experience for their students. Not only does this improve student satisfaction, but it also leads to improved academic results, highlighting the significance of service quality as a critical element of successful online education.

2.4. Gap analysis

The gap analysis displayed in Table 2 offers a thorough summary of the existing research landscape for Project-Based Learning (PBL) in online education. Although previous research has shown that PBL is both achievable and advantageous, mainly when applied to specific software and academic fields, significant areas require attention and resolution. The gaps identified encompass several areas: a dearth of studies examining the long-term effectiveness, limited applicability across different engineering fields and software, inadequate comparative analysis of assessment strategies, minimal understanding of student experiences, and concerns about the scalability and applicability of problem-based learning (PBL) in diverse educational settings. Identifying these limitations emphasizes the necessity for additional research. It also underscores the importance of the audience's role in addressing these gaps, as their contributions could lead to broader and more efficient adoption of PBL in online settings, emphasizing long-term student achievements, other fields of study, alternative evaluation techniques, and the capacity to be implemented in many institutions.

The analysis identifies multiple deficiencies in the existing research on Project-Based Learning (PBL) in online education. Although the practicality of PBL in an online setting has been proven, more research is needed to evaluate its long-term success in student retention, comprehension, and skill application. The present emphasis on Revit software and MEP systems in engineering needs to acknowledge the versatility of PBL in other engineering disciplines and software platforms. Furthermore, the exclusive dependence on project-based evaluations must include a comparison investigation of various online assessment methods to assess their relative effectiveness and scalability. The need for more understanding of student experiences is evident since most talks' focus on the instructor's viewpoint. This highlights the necessity of including student comments to achieve a more equitable perspective, ensuring that all stakeholders are valued and included in the research

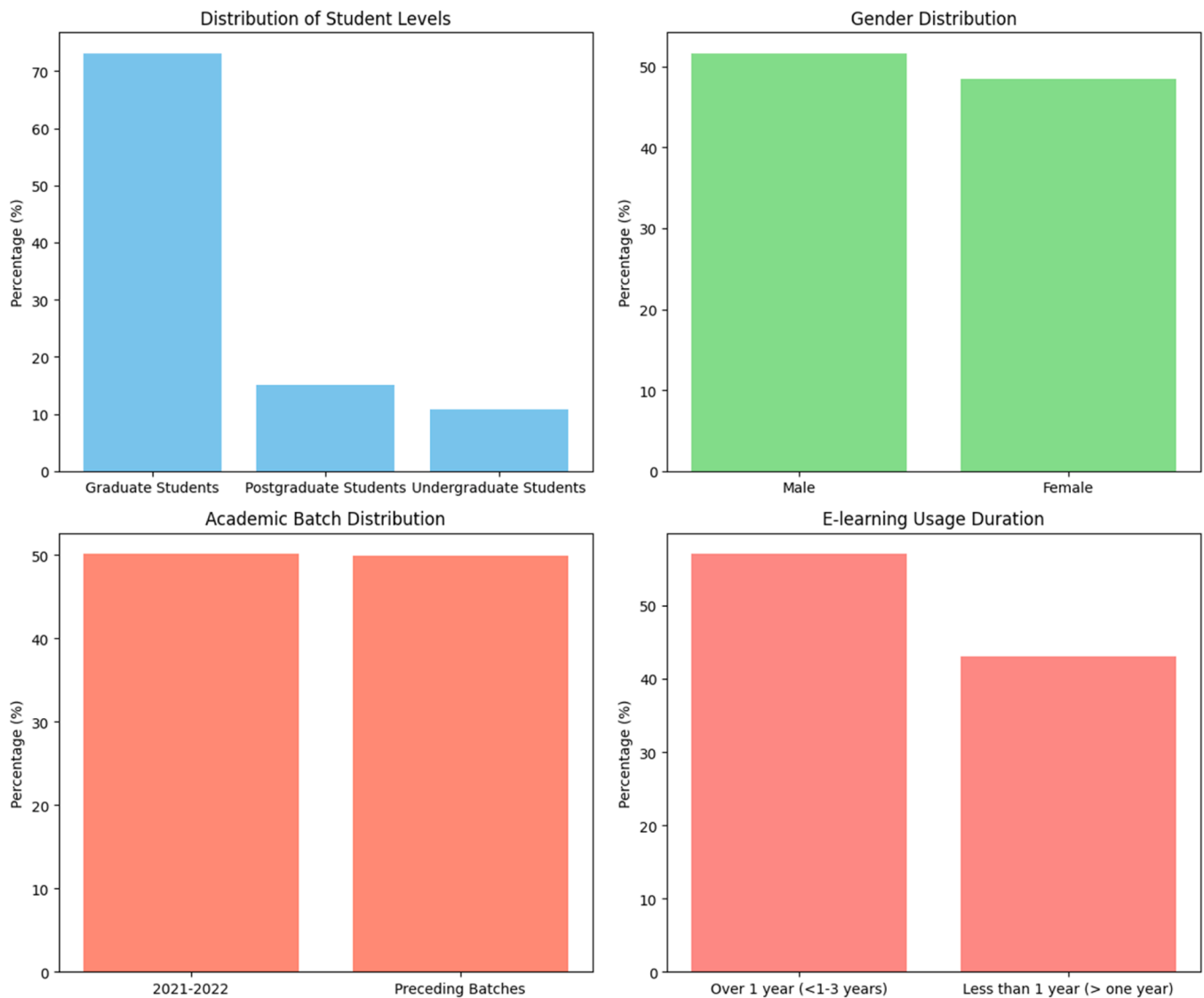


Fig. 1. visually represents the sample data.

process. There needs to be a more comprehensive exploration of the scalability and applicability of PBL in other contexts or with bigger student groups. Existing studies primarily concentrate on individual case studies. These identified deficiencies indicate potential areas for additional research to improve the implementation and comprehension of PBL in online learning settings.

3. Method

This study utilized a quantitative research design to investigate the impact of educational technology implementation on online learning quality during the COVID-19 pandemic. Data was collected from students and instructors who participated in online learning during the pandemic through a structured questionnaire. The questionnaire included items adapted from validated instruments to measure system quality, information quality, and service quality.

Items were adapted to focus on accessibility, reliability, and scalability to measure system quality. Information quality was assessed by examining the information's relevance, accuracy, and timeliness. Service quality was measured, focusing on technical support and communication channels.

Data analysis was conducted using structural equation modeling (SEM) to examine the relationships between educational technology

implementation, system quality, information quality, service quality, and online learning quality. SEM allows for the testing of complex relationships between multiple variables and provides insights into these variables' direct and indirect effects on online learning quality.

Overall, this study comprehensively analyzes the factors influencing online learning quality during the COVID-19 pandemic, highlighting the importance of system quality, information quality, and service quality in enhancing the online learning experience for students and instructors.

3.1. Data collection and analysis

The data collection for this study was executed with precision, focusing on a heterogeneous group of students and lecturers from the Tarbiyah & Teaching Science Faculty across multiple campuses of Islamic State University. Malang, Bandung, Surabaya, and Jogjakarta campuses inclusively represented participants from diverse educational backgrounds. Employing a non-random convenience sampling technique, we sought to gather diverse viewpoints from persons actively involved in these educational environments. Despite the intrinsic constraints of convenience sampling concerning randomization, it enabled us to collect data from a significant sample size of 432 respondents, guaranteeing a comprehensive and representative foundation. Concerning the duration of e-learning utilization, most respondents (57 %)

indicated that they have engaged with the platform for over a year, specifically within the 1 to 3-year range. The remaining 43 % reported a usage duration of less than one year. This trend highlights teachers' growing familiarity and dependence on e-learning resources, signifying a notable educational transformation.

The demographic analysis of the respondents indicated a virtually equal gender distribution, with 51.6 % identifying as male and 48.4 % as female. The equitable gender distribution highlights the diversity within the sample and establishes a robust basis for examining diverse viewpoints on e-learning experiences. Furthermore, the statistics indicated that most e-learning participants belonged to the 2021-2022 academic cohort, comprising 50.1 % of the respondents. This recent cohort embodies a generation of students and instructors that have undergone swift integration and adjustment to e-learning platforms during the COVID-19 epidemic, providing significant insights into the current realm of online education. Concerning the duration of e-learning utilization, most respondents (57 %) indicated that they have engaged with the platform for over a year, specifically within the 1 to 3-year range. The remaining 43 % reported a usage duration of less than one year. This trend highlights educators' growing familiarity and dependence on e-learning resources, signifying a notable educational advancement.

The research included two main analytical techniques: descriptive statistical analysis and structural equation modelling (SEM). Descriptive statistical analysis summarizes and delineates the properties of a dataset, including measures of central tendency (mean, median, mode) and dispersion (standard deviation, variance). This analysis offers a fundamental comprehension of the dataset by delineating trends, patterns, and the general distribution of responses. This study utilized descriptive statistics to elucidate critical dimensions of online learning, including system quality, information quality, and service quality, as reported by students and teachers. Concerning the duration of e-learning utilization, most respondents (57 %) indicated that they have engaged with the platform for over a year, specifically within the 1 to 3-year range. The remaining 43 % reported a usage duration of less than one year. This trend highlights teachers' growing familiarity and dependence on e-learning resources, signifying a notable educational advancement.

In addition to the descriptive analysis, SEM was employed to investigate intricate interactions among variables and to evaluate hypotheses regarding the quality of online learning. This approach integrates parts of component analysis with regression analysis, allowing researchers to investigate observable and latent variables within a theoretical framework. Utilizing SEM, we examined hypotheses regarding causal links, namely the possible impact of educational technology adoption on online learning quality mediated by system quality, information quality, and service quality. SEM enabled us to construct and evaluate a model that demonstrates the interactions and dependencies among these factors. Concerning the duration of e-learning utilization, most respondents (57 %) indicated that they have engaged with the platform for over a year, specifically within the 1 to 3-year range. The remaining 43 % reported a usage duration of less than one year. This trend highlights educators' growing familiarity and dependence on e-learning resources, signifying a notable educational advancement.

The integration of descriptive statistical analysis and SEM offered a thorough method for comprehending the complexities of online learning quality during the COVID-19 epidemic. Descriptive analysis provided an overview of the respondents' demographics and general perceptions, whereas SEM facilitated a more profound investigation into the interrelationships among specific components of the online learning environment. Collectively, these methodologies enabled us to derive significant insights into the determinants of effective online learning experiences and to pinpoint opportunities for enhancement in the execution of educational technology. Figure 1 visually illustrates the sample data, providing a thorough overview of the demographic and consumption factors that support the conclusions of this study.

Fig. 1 visually depicts the sample data, illustrating the main demographic and consumption tendencies discovered in this study. The

Table 1
Study of literature

Author	Aspect	Definition	Importance	Examples
[36]	System Quality	Technical aspects and infrastructure of online learning platforms	Ensures reliability, accessibility, scalability	User interface design, platform stability
[37]	Information Quality	Relevance, accuracy, and credibility of educational content	Influences learning outcomes	Content curation, multimedia integration
[38]	Service Quality	Support services and communication channels within online learning environment	Impacts student engagement, satisfaction	Technical support, communication effectiveness
[39]	Flexibility	Ability of online learning to adapt to different learning styles and schedules	Allows personalized learning experiences	Self-paced courses, asynchronous learning options
[40]	Interactivity	Degree of interaction between students, instructors, and course content	Enhances engagement and knowledge retention	Discussion forums, virtual labs
[41]	Feedback Mechanisms	Availability of mechanisms for providing feedback on student performance	Facilitates improvement and assessment	Automated quizzes, peer assessment
[42]	Content Relevance	Alignment of educational content with learning objectives and real-world applications	Enhances learning relevance	Case studies, industry examples
[43]	Accessibility	Ease of access to online learning resources and platforms	Ensures inclusivity and reach	Mobile compatibility, screen reader support
[44]	Multimedia Integration	Incorporation of various media formats (e.g., videos, simulations) into learning materials	Enhances engagement and understanding	Video lectures, interactive simulations
[45]	Support Services	Availability of academic and technical support for students	Improves learning experience	Tutoring, counseling services

figure presents a comprehensive overview of the participants' profiles by depicting the distribution of respondents according to their educational level, gender, academic batch, and duration of e-learning usage. This visual summary provides a clear and concise representation of the respondents' different backgrounds and experiences, which are essential for comprehending the broader implications of the research.

3.2. Measurement

In each questionnaire, respondents voluntarily provided feedback on the implementation of the e-learning system and the quality of learning from lecturers during the Covid-19 pandemic [65,66,67,68,69]. They rated their experiences on a scale ranging from 1 (very low) to 5 (very high), reflecting their perception of various aspects of the e-learning process.

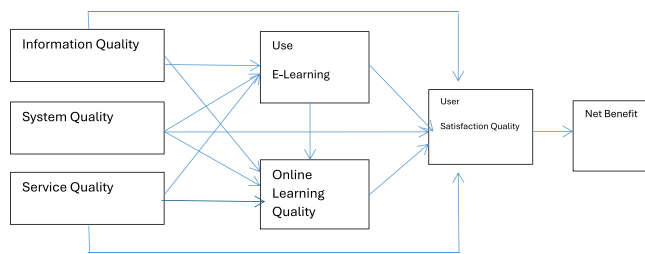


Fig. 2. Modified information system success model (Delone and McLean Model)

Descriptive statistical analysis was employed to evaluate the implementation of the e-learning model and the quality of learning at the Tarbiyah & Teaching Science Faculty within the Islamic State University across Indonesia, focusing on the research variables. Partial Least Square (PLS) analysis was conducted using Smart PLS 3.0. The PLS analysis proceeded through a two-step procedure, initially testing the model and measurements for validity and reliability. Subsequently, the structural model was tested to ascertain the significance of the research hypotheses. The model utilized in this study corresponds to the information system depicted in Figure 1, which assesses the success of e-learning implementation and the quality of online learning across various aspects of the overall information system concerning user satisfaction and benefits. Additional indicators were incorporated based on insights from literature reviews and previous research, with each variable and indicator elucidated in Table 1.

Fig. 2 illustrates the key components of the information system model, highlighting the relationships between different variables and indicators. The model considers factors such as system usability, content relevance, and user support, all of which are crucial for ensuring the success of e-learning initiatives. By incorporating these elements, the model provides a holistic view of the e-learning environment and its impact on user satisfaction and benefits.

As utilized in this study, the modified information system success model extends the traditional framework proposed to capture better the nuances of e-learning implementation and its impact on user satisfaction and benefits [70,71]. This adapted model incorporates additional variables and indicators tailored to the context of online learning, accounting for factors such as the quality of the e-learning system, the effectiveness of online teaching methods, and the overall learning experience [72,73,74]. By integrating these elements into the existing framework, the modified model offers a more comprehensive understanding of the success factors driving user satisfaction and realizing benefits in the e-learning environment.

The model utilized in this study is designed to assess the success of e-learning implementation and the quality of online learning. It depicts an information system that encompasses various aspects, with a particular focus on user satisfaction and benefits. Additional indicators were incorporated into the model based on insights from literature reviews and previous research. These indicators are aimed at providing a comprehensive framework for evaluating the effectiveness and quality of online learning within the context of e-learning implementation.

Table 3 further elaborates on the variables and indicators included in the model, providing a detailed breakdown of each component. This table serves as a guide for researchers and practitioners interested in assessing the quality of online learning and the effectiveness of e-learning implementation. By utilizing this model and its associated indicators, stakeholders can gain valuable insights into the key factors that contribute to a successful e-learning experience.

The quality of information within an e-learning system is reflected in its output and performance, encompassing the capabilities of hardware, software, policies, and procedures to effectively deliver the necessary information to users. It represents the system's ability to meet user needs and expectations regarding information accessibility and relevance.

Service quality, conversely, pertains to the comparison between customer expectations and the perceived level of service received. It focuses on users' overall experience with the e-learning system, considering factors such as responsiveness, reliability, and support.

Assessing the quality of online learning involves evaluating various aspects of the learning experience provided to students by lecturers. This includes criteria such as learning design, activities, delivery strategies, technology integration, assessment methods, and support services. By measuring students' expectations and perceptions using frameworks like SERVQUAL, institutions can gauge the effectiveness of their online learning programs and identify areas for improvement.

User satisfaction in e-learning refers to the response and feedback from students after engaging with the information system and participating in online learning activities. It reflects the extent to which their expectations were met and their overall contentment with the learning experience. Furthermore, the net results of implementing e-learning models during the COVID-19 pandemic encompass the benefits individuals and organizations realize. These benefits may include enhanced accessibility, flexibility, cost-effectiveness, and improved learning outcomes, contributing to the overall success of online education initiatives.

4. Results

The results of the research on online learning implementation at Tarbiyah & Teaching Science Faculty in Islamic State University across Indonesia during the COVID-19 pandemic unveil a comprehensive analysis of the effectiveness and quality of the online learning system. Through meticulous examination, the study sheds light on the strengths and areas for improvement within the system, providing valuable insights for institutional stakeholders. The analysis offers a nuanced understanding of the online learning environment's performance and its impact on student outcomes by assessing various dimensions such as system quality, information quality, service quality, and user satisfaction. These findings serve as a foundation for understanding the intricacies of online learning delivery during challenging times, informing future strategies for enhancing the quality and efficacy of online education.

4.1. Findings on online learning

Implementing online learning at Tarbiyah & Teaching Science Faculty in Islamic State University across Indonesia during the COVID-19 pandemic has yielded promising results, as evidenced by the data analysis presented. The system's overall quality in facilitating online learning through e-learning platforms has been deemed satisfactory, with particularly positive feedback regarding reliability. However, areas are identified for improvement, notably in ensuring the up-to-date nature of the content and bolstering security measures. These findings underscore the importance of continuously refining and updating the online learning infrastructure to meet users' evolving needs and expectations, especially during times of crisis.

Within system quality, adaptability emerges as a critical area requiring attention. While the system is generally considered good regarding usability, speed, and reliability, adaptability stands out as an aspect with room for enhancement. This suggests the online learning system needs to be more responsive and flexible, capable of adapting to technological advancements and changing educational requirements. Prioritizing improvements in adaptability, stability, and ease of use can significantly enhance the online learning environment's overall user experience and effectiveness.

Furthermore, service quality is pivotal in shaping user satisfaction and engagement with the e-learning system. The positive feedback received regarding indicators such as responsiveness, assurance, and empathy indicates a strong foundation in service provision. However, ongoing efforts should be directed toward maintaining and elevating

Table 2
Gap analysis

Area	Current Focus	Identified Gaps	Opportunities for Further Research	Relevant Citations
Long-term Effectiveness	Demonstrates the feasibility of PBL in an online environment.	Lacks exploration of long-term effectiveness in terms of student retention, comprehension, and skill application.	Investigate long-term outcomes of students who completed online PBL courses.	[55,56]
Software and Discipline Scope Assessment Strategy	Focuses on Revit software and MEP systems in engineering. Uses project-based assessment as a primary evaluation method.	Does not address adaptability across different engineering fields or using alternative software tools. Lacks comparative analysis with other online assessment methods to evaluate relative efficacy and scalability.	Study the applicability of PBL with various engineering disciplines and software. Compare PBL assessments with other methods like quizzes, exams, and peer reviews.	[57,58] [59,60]
Student Experience	Discusses course adjustments from the instructor's perspective.	Limited insight into student experiences and feedback during the course.	Incorporate student feedback to provide a more balanced view of online PBL.	[61,62]
Scalability and Applicability	Focuses on a single case study in a specific context.	The study may not fully address how the approach scales or applies to other contexts or larger student groups.	Explore scalability of PBL in online courses across different institutions.	[63,64]

these aspects of service quality to ensure user satisfaction. This involves fostering a supportive and responsive environment for learners, where their needs and concerns are promptly addressed.

To drive meaningful improvements, a strategic approach to prioritizing enhancements is essential. Allocating resources and attention to areas with lower performance, such as content currency, system adaptability, and service responsiveness, can yield significant dividends in enhancing the online learning system's overall effectiveness and user experience. Additionally, leveraging the insights gleaned from user feedback and data analysis can inform targeted interventions and refinements, ultimately fostering a more robust and resilient online learning ecosystem that meets the diverse needs of learners, even amidst challenging circumstances like the COVID-19 pandemic.

As per Table 4, the conditions of online learning implementation are segmented into three main categories: System Quality, Information, and Services. Each category is further broken down into specific indicators to evaluate the performance of the online learning system comprehensively. System Quality indicators include Usability, Adaptability, Speed, and Reliability. Information quality is assessed through Up-to-date, Security, and Personalization indicators. Finally, Service Quality encompasses indicators like Responsiveness, Assurance, and Empathy. The data presented in Table 2 offers a structured overview of the online learning environment, allowing stakeholders to identify areas of strength and areas needing improvement across these critical dimensions.

Based on the data, online learning at Tarbiyah & Teaching Science Faculty in Islamic State University throughout Indonesia during the COVID-19 pandemic has been generally successful, with several vital indicators reflecting positive outcomes. Firstly, the overall quality of the online learning system is considered good, with strengths observed in practice exams or practice problems and in the contributions of presentations and case studies to the system's utilization. Additionally, user satisfaction with the system is notably high, with indicators such as overall satisfaction, experience satisfaction, and enjoyment of online learning activities receiving positive ratings.

However, areas are identified for improvement, particularly in the quality of lecturers' online learning services. The dimensions of empathy and tangibles have been highlighted as needing attention, suggesting a need for enhancement in providing emotional support and tangible resources to learners. Priority areas for improvement include empathy, responsibility, and assurance, followed by reliability and responsiveness.

Despite these areas for improvement, implementing online learning models through e-learning has mainly been successful, especially considering the challenges posed by the COVID-19 pandemic. The system has demonstrated effectiveness in achieving academic success and generating cost and time savings for both students and educators. This underscores the importance of continued investment and refinement in online learning infrastructure to ensure its ongoing success and

Table 3
Measurement scales.

Parameter	Measurement Item
Information quality	Completeness Clearly written Personalization Accuracy Timelines Relevance Up to date Security
Systems quality	Easy to use Adaptability Reliability Speed
Service quality	Responsiveness Assurance Empathy
Usage quality	PowerPoint slide Audio Script Discussion board Case studies Practice problems Excel tutorials
Online Learning quality	Online learning design Quality Online learning activities, Quality Delivery strategy Quality Learning media and technology Quality Evaluation of learning success Quality
User Satisfaction	Overall satisfaction Enjoyable experience
Net Benefits	Enhanced learning Empowered Time savings Academic success Cost efficiency Overall success

relevance in the education landscape.

The questionnaire employed in this study was carefully crafted to address all pertinent topics about the research's comprehensive aims. The questionnaire consisted of a diverse range of well-organized questions specifically designed to collect data on respondents' perspectives, attitudes, and experiences about the subject matter of the study. Every question was meticulously crafted to ensure clarity and simplicity, reducing potential confusion, and enhancing the precision of the answers. In addition, the questionnaire was partitioned into distinct sections, each designed to investigate specific details about the variables being studied, such as the quality of service, user happiness, and the system's effectiveness.

To obtain precise measurements of respondents' answers, most of the questions were given in a closed-ended style utilizing a Likert scale. This

Table 4

Conditions Online learning implementation: System quality, information, and services

Construct	Indicator	Mnemonic	Mean	Factor loading	Composite reliability ^a	AVE ^c
Information Quality	Completeness	IQ1	4.086	0.879	0.949	0.699
	Clearly written	IQ2	4.032	0.863		
	Personalization	IQ3	4.000	0.882		
	Accuracy	IQ4	4.011	0.865		
	Timelines	IQ5	4.054	0.805		
	Relevance	IQ6	4.022	0.860		
	Up to date	IQ7	3.914	0.785		
	Security	IQ8	4.226	0.738		
Systems Quality		Mean	4, 043		0.916	0.733
	Usability	SQ10	3.925	0.855		
	Adaptability	SQ11	3.882	0.871		
	Reliability	SQ12	3.903	0.851		
	Speed	SQ9	3.968	0.847		
		Mean	3,919			
Service Quality	Responsiveness	SEQ13	3.968	0.924	0.942	0.845
	Assurance	SEQ14	3.957	0.914		
	Empathy	SEQ15	3.957	0.919		
		Mean	3,960			

scale enabled participants to express their concurrence or discordance with assertions, commonly from "strongly disagree" to "strongly agree." This method offered a reliable structure for gathering data that could be subjected to statistical analysis, facilitating the detection of prevalent patterns or trends within the population under investigation. In addition, a few open-ended questions were included to supplement the quantitative data. These questions allowed respondents to express their perspectives, thoughts, or experiences that the closed-ended options may not have covered.

The responses obtained from the questionnaire were subsequently subjected to thorough analysis to detect correlations and trends that could either support or contradict the research assumptions. The analysis procedure entailed applying appropriate statistical techniques to process the quantitative data. In contrast, the qualitative data obtained from open-ended questions were examined using a theme approach to reveal significant concerns and gain deeper insights. The analysis gave a robust basis for deriving meaningful conclusions and facilitated comprehension of the primary aspects influencing the research topic. Additionally, it provided valuable recommendations for future improvement.

Table 5 displays the feedback on user satisfaction with e-learning, providing a concise overview of the students' comments and feedback regarding their experiences with the e-learning platform. The table comprises essential inquiries about general excellence, user-friendliness, clarity of material, responsiveness of support, and chances for involvement offered by the platform. The responses provide insights into the success of the e-learning experience from the student's perspective, showcasing both areas of satisfaction and suggestions for improvement.

Table 6 presents a detailed breakdown of conditions related to online learning, learning quality, user satisfaction, and net benefits at Tarbiyah & Teaching Science Faculty in Islamic State University throughout Indonesia. It encompasses various indicators that provide insights into the effectiveness and success of online learning implementation during the COVID-19 pandemic.

The indicators under the "Conditions of Use" category include usability and the quality of online learning, reflecting the online learning platform's ease of use and effectiveness. User satisfaction indicators gauge the overall satisfaction levels of users with the system, including factors such as experience satisfaction and enjoyment of online learning activities. Net benefits or results are assessed based on indicators like academic success, cost savings, and time savings, reflecting the tangible outcomes and benefits of the online learning experience.

The data presented in Table 6 indicate that the online learning implementation at Tarbiyah & Teaching Science Faculty has been largely successful, with positive ratings across various indicators. Notably, practice exams or practice problems are considered good,

highlighting the effectiveness of assessment practices within the online learning environment. Additionally, high user satisfaction levels indicate a positive experience and engagement with the online learning platform.

Overall, the data from Table 6 suggest that while the online learning implementation has been successful, there is still room for refinement and improvement to enhance the quality of the learning experience further and ensure continued user satisfaction and positive outcomes. This underscores the importance of ongoing assessment, feedback collection, and iterative improvement in online education.

However, areas are identified for improvement, particularly in the quality of lecturers' online learning services. Dimensions such as empathy and tangibles have been identified as needing attention, suggesting a need for enhancement in providing emotional support and tangible resources to learners. Priority areas for improvement include empathy, responsibility, and assurance, followed by reliability and responsiveness.

Besides descriptive statistical analysis, this research implements structural equation modeling using Smart PLS 3.0. Mardia's multivariate test for data normality showed significant skewness ($\beta = 6.33$, $p < 0.001$) and kurtosis ($\beta = 144.49$, $p < 0.001$), indicating a departure from normality. Consequently, PLS-SEM is suitable for data processing. The reliability and validity (convergent and discriminant) of the measurement model were tested based on the results of the PLS algorithm using several indicators. R2 and f2 values are used to assess the model's explanatory power and effect size. Using PLS-SEM, the Stone-Geisser test was performed to ensure the model's predictive power.

All measurement items strongly represent their respective constructs and meet the criteria for convergent validity, as shown in Table 7. Cronbach's alpha values ranged from 0.87 to 0.95, indicating high internal consistency and reliability for each construct. Composite reliability (CR) values exceeded the threshold of 0.7, further supporting the reliability of the constructs. Additionally, the estimated average variance extracted (AVE) values surpassed the recommended threshold of 0.5, providing sufficient evidence of convergent validity for the measurement.

The study delves into multiple aspects of e-learning quality, including Information Quality, System Quality, Service Quality, Use Quality, Online Learning Quality, User Satisfaction, and Net Benefits. Each of these elements is a crucial determinant of the overall efficacy and user experience of e-learning platforms. Understanding the interplay and impact of these factors is not just important, but it's also enlightening for improving the design and provision of e-learning services.

Information Quality is about the content's precision, pertinence, and promptness sent via the e-learning platform. System Quality refers to the

Table 5
User satisfaction feedback in e-learning.

Question	Response Options	Feedback Summary
How satisfied are you with the overall quality of the e-learning platform?	Very Satisfied, Satisfied, Neutral, Dissatisfied, Very Dissatisfied	Most students were highly satisfied with the overall quality of the platform. While several individuals suggested that the navigation could be improved, this did not overshadow their positive experience.
How easy is it to navigate and use the e-learning platform?	Very Easy, Easy, Neutral, Difficult, Very Difficult	Most students regarded the platform as easily navigable. However, some noted that the user interface could be more intuitive.
How satisfied are you with the quality and clarity of the content provided in the e-learning modules?	Very Satisfied, Satisfied, Neutral, Dissatisfied, Very Dissatisfied	Most students expressed satisfaction with the quality and clarity of the content. However, a few students expressed a desire for more interactive elements to further enhance their learning experience.
How responsive and helpful is the support provided (technical or instructional) on the e-learning platform?	Very Responsive and Helpful, Responsive and Helpful, Neutral, Unresponsive and Unhelpful, Very Unresponsive and Unhelpful	Feedback revealed that the support provided was prompt and beneficial, while there were recommendations for enhancing the efficiency of technical assistance.
How likely are you to recommend this e-learning platform to your peers?	Very Likely, Likely, Neutral, Unlikely, Very Unlikely	Most students expressed their willingness to recommend the platform to their classmates, which is a strong testament to their high level of satisfaction with the e-learning experience.
How effective do you find the e-learning platform in enhancing your learning experience compared to traditional classroom settings?	Very Effective, Effective, Neutral, Ineffective, Very Ineffective	The platform was widely regarded as efficacious in augmenting learning, while a few pupils expressed the notion that it may be further improved with supplementary interactive functionalities.
How satisfied are you with the interaction and engagement opportunities provided by the e-learning platform?	Very Satisfied, Satisfied, Neutral, Dissatisfied, Very Dissatisfied	The level of interaction and involvement was met with a combination of positive and negative feedback. While many individuals expressed satisfaction, there were suggestions for improving the discussion forums and collaborative tools.
What aspects of the e-learning platform do you feel need improvement?	Open-ended	Students offered comprehensive input regarding areas that should be enhanced, including highlighting navigation, interaction features, and the speed at which assistance responds.

technical elements of a system, including its ease of navigation, reliability, and user interface. Service Quality is about providing support services to users, including technical assistance and instructional guidance. Quality is about the level of effectiveness with which learners utilize the platform, whereas Online Learning Quality evaluates the overall experience and outcomes of the learning process. These factors are not just individual components, but they are interconnected, creating a web of influence that keeps the audience intrigued and engaged.

User Satisfaction is a pivotal gauge of how well the e-learning

platform meets the needs and expectations of its users. It is closely linked to Net Benefits, which represent the perceived value and advantages gained from using the platform. These constructs are not isolated, but rather interconnected, meaning that enhancements in one area can lead to positive outcomes in other areas. For instance, a boost in Information Quality can directly enhance User Satisfaction, leading to a subsequent increase in perceived Net Benefits.

Table 8 serves as a visual representation of the discriminant validity. It compares the square root of the Average Variance Extracted (AVE) for each construct with the correlations between them to assess their distinctiveness. The table demonstrates that the diagonal values, which represent the square root of AVE, are greater than the off-diagonal correlation values. This indicates that each construct is distinct and sufficiently different from the others, confirming that the model effectively evaluates the desired concepts without significant overlap.

The diagonal values, namely 0.836 for Information Quality and 0.856 for System Quality, indicate that these constructs account for more significant variance in their respective items than in their correlations with other constructs. The off-diagonal values indicate relationships between many constructs, including Information Quality and System Quality (0.892) and Use Quality and Online Learning Quality (0.863). The correlation values constantly fall below the square root of AVE for each concept, indicating that the model satisfies the requirement for discriminant validity.

The online learning system boasts numerous strengths that significantly enhance its educational value and accessibility. Foremost, it offers unparalleled convenience and flexibility, allowing learners to access various educational resources virtually anywhere, anytime. This flexibility accommodates diverse schedules and learning styles, empowering individuals to tailor their learning experiences to suit their needs. Additionally, the scalability of online learning systems ensures that they can accommodate many students without compromising the quality of education. This scalability is particularly advantageous for institutions looking to reach a wider audience and offer more inclusive educational opportunities.

However, despite these strengths, there are several areas where online learning systems can be improved. One critical area is technical support, where students and instructors often face challenges that require immediate assistance. Improving the responsiveness and availability of technical support can significantly enhance the overall user experience. Furthermore, enhancing the user interface to be more intuitive and user-friendly can help learners navigate the system more efficiently, leading to a more engaging and practical learning experience. Additionally, ensuring the reliability and stability of the system is essential to minimize disruptions and downtime, thereby maintaining a seamless learning environment for all users.

Regarding information quality, online learning systems excel in providing up-to-date and relevant educational content. They can integrate multimedia elements such as videos, simulations, and quizzes to enhance the learning experience. However, there is room for improvement in content curation and interactivity. Ensuring the content is accurate, credible, and up to date is crucial for maintaining the system's credibility and educational value. Moreover, increasing the level of interactivity can help engage students more effectively and promote active learning, leading to better retention and understanding of the material. By addressing these areas for improvement, online learning systems can further enhance their effectiveness and provide a more enriching learning experience for all users.

Furthermore, the model demonstrates a strong ability to explain the data, as indicated by the high R-squared (R^2) values in Table 9. The R^2 values indicate the amount of variability in the dependent variables that can be accounted for by the independent variables. The strong R^2 values imply that the model successfully explains and predicts the observed results by accounting for significant variance in the endogenous factors.

The absence of multicollinearity, as demonstrated by the variance inflation factor (VIF) scores in Table 8, is a testament to the

Table 6
Conditions of use, learning quality, user satisfaction and net benefits

Construct	Indicator	Mnemonic	Mean	Factor loading	Composite reliability ^a	AVE ^c
Use Quality	Power point slide	KP16	3.871	0.856	0.960	0.776
	Audio	KP17	3.763	0.881		
	Script	KP18	3.753	0.911		
	Discussion board	KP19	3.796	0.894		
	Case studies	KP20	3.882	0.905		
	Practice problems	KP21	4.054	0.855		
	Excel tutorials	KP22	3.882	0.861		
		<i>Mean</i>	3,857			
Online Learning Quality	Online learning design <i>Quality</i>	TG23	3.882	0.902	0.954	0.807
	Online learning activities, <i>Quality</i>	RB24	3.914	0.914		
	Delivery strategy <i>Quality</i>	RS25	3.968	0.917		
	Learning media and technology <i>Quality</i>	AS26	3.989	0.902		
	Evaluation of learning success <i>Quality</i>	EM27	4.032	0.854		
		<i>Mean</i>	3,957			
User Satisfaction	Overall satisfaction	US28	3.871	0.911	0.961	0.803
	Enjoyable experience	US29	3.763	0.887		
		US30	3.753	0.901		
		US31	3.796	0.928		
		US32	3.882	0.897		
		US33	4.054	0.851		
		<i>Mean</i>	3,853			
Net Benefits	Enhanced learning	NB34	3.935	0.904	0.959	0.795
	Empowered	NB35	3.903	0.895		
	Time savings	NB36	3.957	0.909		
	Academic success	NB37	4.032	0.932		
	Cost efficiency	NB38	3.914	0.817		
	Overall success	NB39	4.011	0.888		
		<i>Mean</i>	3,958			

Table 7
Reliability and Validity Measures

Latent Variable	Cronbach's alpha	Composite reliability
Information Quality	0.938	0.942
User Satisfaction	0.951	0.952
Online Learning Quality	0.940	0.941
Use Quality	0.952	0.952
Net Benefit	0.948	0.951
Service Quality	0.908	0.909
System Quality	0.879	0.881

thoroughness of our research. With scores significantly below the threshold value of 3.3, the model's predictor variables have a low correlation level, reducing the risk of multicollinearity influencing the findings. The Stone-Geisser test further confirms the strong predictive ability of all internal latent variables, with all Q^2 values (0.99) surpassing the threshold of 0.35. This suggests that our model accurately forecasts the endogenous constructs' behavior, further validating our study's comprehensive nature.

Essential insights into the variables affecting student happiness and the efficacy of online learning platforms are provided by the Partial Least Squares (PLS) modeling carried out in this study. High-quality information considerably improves students' evaluations of the overall Quality of online learning; according to the analysis, information quality has a substantial positive effect on online learning quality (Path Coefficient = 0.570, $P = 0.000$). Moreover, it is shown that there is a strong

correlation between higher satisfaction levels and the perceived advantages that students believe they receive from their online learning experiences (Path Coefficient = 0.621, $P = 0.000$). User satisfaction also has a substantial impact on the Net Benefit.

Moreover, our study uncovers a robust link between User pleasure and Online Learning Quality (Path Coefficient = 0.419, $P = 0.013$), underscoring the direct connection between student enjoyment and the Quality of online instruction. The correlation between online learning quality and use Quality is not just significant, but substantial (Path Coefficient = 0.589, $P = 0.000$), indicating that higher learning quality also enhances students' ability to engage with and utilize the online learning environment. Furthermore, Use Quality is significantly influenced by Service Quality (Path Coefficient = 0.232, $P = 0.038$), suggesting that improved service quality fosters more effective use of the online learning platform.

The study also identified a few less significant associations, including the negligible effects of system and information quality on user

Table 9
R-Square

Variable	R-square
User Satisfaction	0.706
Online Learning Quality	0.728
Use Quality	0.791
Net Benefit	0.855

Table 8
Discriminant validity

	Information quality	System quality	Service quality	Use quality	Online learning quality	User Satisfaction	Net Benefits
Information Quality	0.836						
System Quality	0.892	0.856					
Service Quality	0.862	0.847	0.919				
Use Quality	0.797	0.806	0.780	0.881			
Online Learning Quality	0.840	0.809	0.752	0.863	0.898		
User Satisfaction	0.763	0.710	0.743	0.780	0.804	0.896	
Net Benefits	0.835	0.784	0.768	0.784	0.848	0.901	0.892

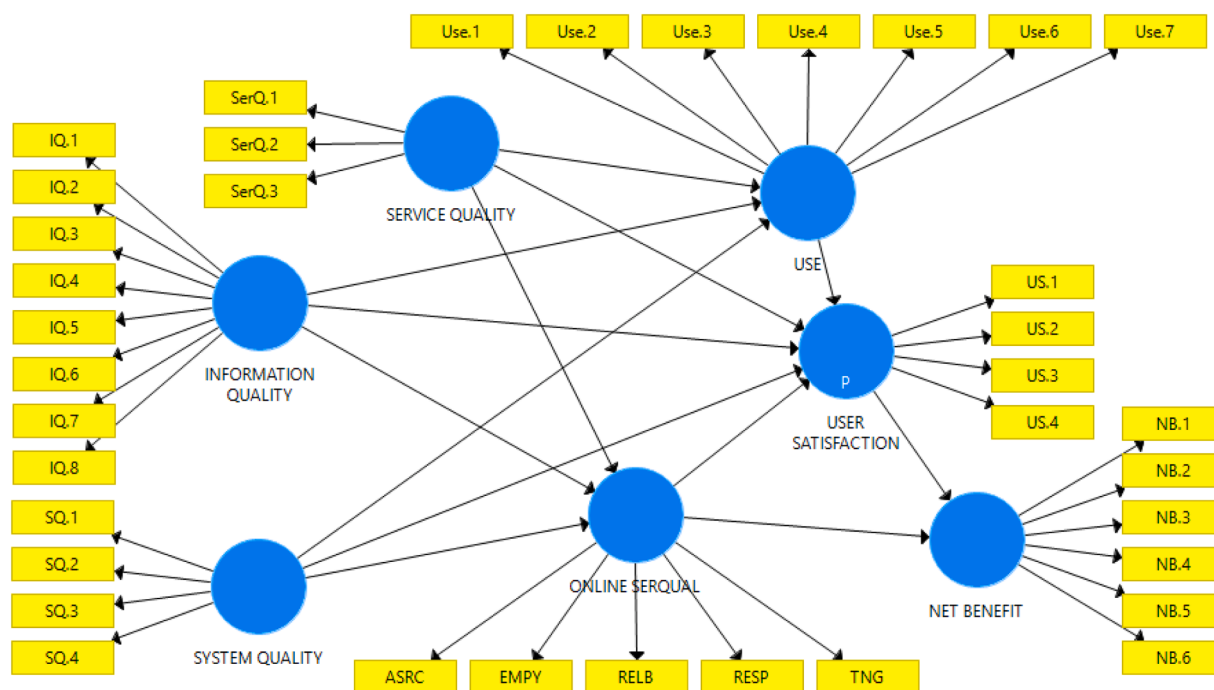


Fig. 3. illustrates the PLS modelling conducted in the study.

satisfaction. According to these results, even if these elements might not directly raise user happiness, they make a difference in other ways for the whole online learning experience.

The PLS modeling in this study underscores the interconnectedness of instructional Quality, service quality, and the observable outcomes students achieve, thereby highlighting the intricate nature of student satisfaction in online learning environments. These findings offer practical recommendations for educators and educational institutions seeking to enhance virtual learning experiences. Enhancing the Quality of resources, guidance, and support can significantly enhance learners' satisfaction and the overall effectiveness of virtual learning environments.

The direct consequences on student satisfaction in online learning are highlighted by the study of Fig. 3, emphasizing the caliber of lecturer-delivered instruction. The correlation coefficient for this relationship is 0.419, suggesting a robust and affirmative association between student satisfaction levels and the perceived quality of education. This research emphasizes how important it is for teachers to influence how students perceive and interact with online learning settings. Higher levels of student satisfaction are significantly correlated with lecturers' effectiveness and involvement, highlighting the significance of excellent teaching in guaranteeing a happy learning environment. With a coefficient value of 0.621, examining student satisfaction concerning their net performance suggests an even stronger association. This finding emphasizes how important concrete outcomes are in determining students' satisfaction with their online learning experiences. Examples of these tangible outcomes include academic performance, skill development, and overall learning achievements. The focus on net results implies that student happiness is influenced by more than just the caliber of instruction; it is also influenced by the more comprehensive educational outcomes that students achieve. This all-encompassing method of evaluating student happiness suggests that meaningful outcomes and high-quality training are essential for creating a positive online learning environment.

The results above highlight the complex characteristics of student contentment within virtual learning settings. Several factors affect student satisfaction, and one of the most important is the caliber of instruction professors provide. Good instruction is essential to promoting

excellent student outcomes since it immediately affects students' perceptions of their learning experiences due to the efficacy and engagement of instructors.

However, ensuring student happiness requires more than just providing high-quality training. The observable results that students obtain during their online learning experience enhance it. The accomplishment of learning objectives, skill development, and academic success are important factors that affect students' overall satisfaction. These observable outcomes are crucial in influencing students' opinions of their online learning experience and provide proof of the efficacy of the educational process.

The relationship between the caliber of instruction and the results attained shows how these two factors are related. While the achievement of educational objectives provides the groundwork for learning, instructional effectiveness reinforces and validates the learning process. When combined, they create a thorough foundation that has a big impact on student satisfaction. Given their interdependence, it is necessary to address both aspects simultaneously to maximize the benefits of online learning.

These observations provide insightful advice for teachers and organizations looking to raise student satisfaction levels. Developing a rewarding online learning environment requires a comprehensive strategy that considers both the caliber of instruction and student results. By concentrating on both, teachers may better address their students' varied requirements, which will ultimately result in more satisfied learners and more fruitful online learning environments.

4.2. Key outcome summary analysis

The Key Outcome, Summary Analysis of the research on online learning implementation at Tarbiyah & Teaching Science Faculty in Islamic State University across Indonesia during the COVID-19 pandemic reveals crucial insights into the effectiveness of the online learning system. The analysis highlights the overall satisfactory quality of the system, showcasing its resilience and adaptability in navigating the challenges posed by the pandemic. Despite the disruptions, the system demonstrated commendable reliability in delivering educational content to users, reflecting the institution's commitment to maintaining

continuity in education amidst unprecedented circumstances.

Furthermore, the analysis identifies specific strengths of the online learning system, such as its reliability in content delivery. However, it also highlights areas requiring improvement, notably content currency, and security measures. These findings provide valuable guidance for institutional stakeholders to focus their efforts on enhancing the system's efficacy and relevance, ensuring it meets the evolving needs of learners in a rapidly changing educational landscape.

A key takeaway from the analysis is the importance of adaptability and responsiveness in online learning environments. The study emphasizes the need for institutions to proactively adapt to technological advancements and changing educational requirements to serve their learners better. Institutions can enhance the learning experience and effectively navigate dynamic learning environments by fostering adaptability and responsiveness.

Moreover, the analysis underscores the significance of service quality in shaping user satisfaction and engagement with the online learning system. While user satisfaction levels were generally high, the study highlights the importance of continuous investment in service quality to maintain a supportive and responsive learning environment. Prioritizing service quality can improve user satisfaction and ultimately enhance the overall effectiveness of the online learning experience.

In conclusion, the Key Outcome Summary Analysis offers valuable insights for researchers and practitioners in online education. By leveraging the identified strengths and areas for improvement, institutions can innovate and adapt their online learning offerings to meet learners' needs better. Additionally, the analysis emphasizes the importance of ongoing research and investment in technological advancements to support the continuous evolution of online learning practices.

5. Discussion, conclusion, recommendation

In discussing the findings of this research, it becomes evident that the quality of e-learning systems and online instruction significantly influences student satisfaction and the overall success of academic endeavors. These results underscore the importance of embracing technological advancements and adapting educational practices to the evolving digital landscape. Amidst the challenges posed by the COVID-19 pandemic, online learning has emerged as a vital component of the education system, necessitating a comprehensive understanding of its impact on student learning experiences and outcomes. Therefore, this discussion delves into the implications of the study findings, offering insights into the future direction of educational practices and policies.

In conclusion, the study highlights the critical role of e-learning systems and online instruction quality in shaping student satisfaction and academic success. By assessing the factors that influence these variables through a modified information system success model, valuable insights are gained into the dynamics of online learning environments. The findings emphasize the need for continuous improvement in e-learning infrastructure, pedagogical practices, and support services to enhance student satisfaction and maximize the benefits of online learning. Additionally, the study underscores the significance of innovative teaching techniques and blended learning models in catering to diverse student needs and preferences.

Based on the research findings, several recommendations can be made further to enhance the quality and effectiveness of online learning programs. Educational institutions, including the Tarbiyah & Teaching Science Faculty at Islamic State University, should prioritize student satisfaction assessments to identify areas for improvement and inform policy decisions. Furthermore, there is a need for ongoing professional development initiatives to empower lecturers with the skills and resources needed to excel in online teaching environments. Moreover, institutions must invest in robust e-learning infrastructure and support services to ensure seamless and engaging learning experiences for students. Finally, collaboration among stakeholders, including government

agencies, universities, and educational technology providers, is essential to drive innovation and address the evolving needs of learners in the digital age. By implementing these recommendations, institutions can create inclusive and effective online learning environments that foster student success and academic excellence.

6.1. Discussion

The research offers critical insights into the quality and efficacy of the online learning method adopted at the Tarbiyah & Teaching Science Faculty at Indonesian Islamic State Universities during the COVID-19 pandemic. The analysis indicates that system quality, especially dependability and usability, enabled students to access and engage with course information efficiently, even under a broad disruption. Furthermore, the quality of information, including content relevancy, accuracy, and timeliness, favorably influenced the learning experience. Nonetheless, service quality, particularly regarding response and communication support, has been identified as a domain requiring enhancement. Students needed help obtaining timely technical assistance, which adversely affected their happiness with the educational experience.

These findings strongly correspond with earlier research highlighting the importance of system dependability and information quality in online education. Research in analogous educational settings demonstrates that a robust system architecture greatly enhances user satisfaction by offering a consistent learning platform, especially during periods of disturbance. Furthermore, previous studies have established that service quality, encompassing sufficient technical assistance and effective communication channels, is crucial for fostering a conducive online learning environment. This study indicates a marginally inferior service quality performance compared to previous research, implying a necessity for improved responsiveness and support services to meet the benchmarks of leading online learning platforms.

This comparison underscores the need for the ongoing enhancement of online learning systems. Although system dependability and usability are fundamental, sustaining excellent service quality is equally essential for fostering a comprehensive, student-centered online learning experience. The study's findings emphasize that factors outside system quality are necessary to optimize student happiness. It is essential to provide responsible and accessible support services to resolve technical or instructional problems swiftly. This insight corresponds with international best practices, emphasizing the necessity of a balanced strategy that integrates dependable system architecture with comprehensive support services to establish an effective learning environment.

Moreover, the study enhances the overarching dialogue regarding online education in crises exemplified by the COVID-19 pandemic. It underscores the necessity for adaptation and resilience within the digital platform and the services that facilitate its utilization. In contrast to conventional classroom settings, online education necessitates increased technical assistance and adaptability to manage unforeseen obstacles, such as system failures or access difficulties. The study endorses the idea that crisis-driven online education must integrate adaptive solutions to enable institutions to swiftly address students' changing requirements, thereby improving the overall resilience of the educational environment.

This research indicates that although the online learning system of the Tarbiyah & Teaching Science Faculty fulfils numerous fundamental criteria, improvements in service quality would significantly increase the student experience. Institutions can enhance a more holistic and gratifying online learning experience by augmenting responsiveness and communication within support services. These findings necessitate ongoing assessment and specific enhancements, indicating that robust and flexible online learning systems are essential for addressing students' educational requirements, especially in difficult situations. This holistic strategy, combining strong system quality with improved service support, can act as a prototype for future advancements in online education across diverse institutions.

6.2. Interpretation of results

The study's findings reveal that participants perceive the technical features, infrastructure, and instructional content offered by online learning platforms to be of high quality, as indicated by the high mean scores for system quality (SQ) and information quality (IQ). These results indicate that the platforms utilized for online learning successfully fulfill the requirements of students and instructors regarding accessibility, dependability, and the pertinence of educational resources. The robust performance in these domains suggests that the fundamental components of the online learning setting are highly developed, and users generally have a favorable experience with the technological and informational aspects of these platforms.

Nevertheless, the marginally reduced average score for service quality (SQ) indicates potential areas for enhancement within the online learning setting, particularly in support services and communication channels. System quality and information quality are essential for successful online education delivery. However, service quality is vital to ensuring user satisfaction and engagement. The lower score indicates that students and teachers may need help receiving prompt and practical assistance or that communication within the platform may need to be sufficiently efficient and responsive. Addressing these deficiencies makes it possible to significantly improve the overall user experience and facilitate a smoother learning process.

Structural equation modeling (SEM) analysis provides a clearer understanding of the connection between the deployment of educational technology (ETI) and the essential elements of online learning quality. The notable benefits of ETI on system quality (SQ), information quality (IQ), and service quality (SQ) indicate that incorporating modern educational technology is crucial for improving these components of the online learning environment. This discovery is consistent with the goals and theoretical framework of the study, which highlights the significance of utilizing technology to enhance the functioning, distribution of information, and support systems in online education. By efficiently integrating educational technology, schools may guarantee the strength, comprehensiveness, and user-friendliness of their online platforms.

In addition, the SEM analysis demonstrates that both system quality (SQ) and information quality (IQ) have substantial beneficial effects on the overall quality of online learning (OLQ). These two components are crucial in determining the effectiveness of online education. Optimal system quality guarantees a dependable and easily accessible platform, enabling students to concentrate on their studies without being impeded by technological obstacles. Additionally, good information quality guarantees the content's accuracy, relevance, and currency, hence promoting meaningful learning experiences. Collectively, these variables enhance the online learning environment, fostering student achievement.

The results indicate that although the system and information quality are robust, there is a distinct requirement to prioritize the enhancement of service quality in order to get a more equitable and all-encompassing enhancement in online learning environments. Enhancing service quality may entail allocating resources towards enhancing technical assistance, optimizing communication channels, and offering supplementary tools to facilitate user navigation on the platform. These enhancements would enhance user enjoyment and contribute to a more immersive and helpful learning experience, promoting higher levels of student retention and achievement.

Furthermore, the favorable impacts of implementing educational technology (ETI) on the quality of systems, information, and services suggest that ongoing investment in and advancement of educational technologies are crucial for upholding and improving the quality of online learning. Institutions should prioritize continuous reviews and modifications to their technical infrastructure to guarantee that they are keeping up with innovations in digital education. By adopting this approach, educational institutions may effectively tackle any developing obstacles and consistently deliver a superior educational

experience that caters to the changing requirements of their students and teachers.

To summarize, the study's results emphasize the significance of employing a comprehensive strategy to enhance the quality of online learning. Improving assistance and communication is essential for achieving excellence in online education, even while the system and information quality are already sound. Moreover, the significance of incorporating educational technology to facilitate these enhancements cannot be emphasized enough. In order to keep up with the growth and development of online learning, institutions need to take proactive measures to improve every aspect of their platforms. This includes ensuring the platforms are dependable, informative, and supportive, creating a conducive learning environment for all users.

6.3. Implications for Tarbiyah & teaching science faculty

The results of this study have significant consequences for the Tarbiyah & Teaching Science Faculty. A necessary consequence is the requirement for a deliberate investment in specific instructional technology, such as learning management systems, virtual classrooms, and interactive learning tools, and their efficient deployment. By prioritizing this investment, the faculty may significantly improve the quality of the online learning environment, especially in areas such as the quality of the system, the quality of information, and the quality of service. These enhancements can create a more resilient online learning environment that is dependable, easy to use and offers a wealth of pertinent and current educational material. In addition, improving service quality by enhancing technical assistance and optimizing communication channels will directly enhance the satisfaction and effectiveness of students' learning experiences.

Furthermore, the study emphasizes the crucial need for continuous monitoring and evaluation of the online learning environment. The Tarbiyah & Teaching Science Faculty must design a systematic procedure to evaluate the effectiveness of its online learning system, with active participation from faculty members. Periodic evaluations of system, information, and service quality, led by faculty members, will allow the faculty to pinpoint areas needing attention and enhancement. This proactive strategy guarantees that the online learning experience remains efficient and captivating, thus averting possible problems from becoming significant barriers to student achievement. Continuous monitoring, led by faculty members, enables the faculty to promptly adjust to emerging obstacles and opportunities, ensuring that the online learning environment remains dynamic and sensitive to the requirements of both students and instructors.

The study emphasizes the importance of implementing educational technology effectively and having quality assurance procedures to sustain and enhance the quality of online learning. At the Tarbiyah & Teaching Science Faculty, this may entail implementing optimal strategies for deploying educational technology and guaranteeing the utilization of state-of-the-art platforms and tools that are easy to use. Implementing quality assurance measures, such as frequent feedback loops and performance indicators, will be essential for upholding superior levels of system performance, content relevancy, and service efficacy. By methodically addressing these factors, the faculty may establish a more efficient and successful online learning environment that fulfills the changing requirements of its academic community.

Moreover, the results indicate that by prioritizing the areas suggested for enhancement, the faculty may effectively improve the online learning experience for students and instructors. However, it's important to note that implementing these enhancements may come with challenges such as resource constraints and technical difficulties. This may entail implementing targeted measures such as enhancing the current technology framework to facilitate more interactive and collaborative learning encounters, enhancing, and broadening the digital content repository, and enhancing the promptness and accessibility of technical support services. Overcoming these challenges and

implementing these enhancements will fill existing deficiencies and establish the faculty as a pioneer in cutting-edge online education among the wider academic community.

The consequences also apply to the faculty's approach to faculty development and training. To fully optimize the advantages of advanced educational technologies and online learning platforms, the Tarbiyah & Teaching Science Faculty may need to allocate resources towards continuous professional development for its instructors. This course aims to provide faculty members with the essential skills and knowledge to use new technologies and instructional techniques online effectively. By providing instructors with these tools, the faculty can guarantee that the level of instruction stays excellent, even as the educational environment increasingly adopts digital and hybrid learning models.

Furthermore, the results emphasize the necessity of adopting a student-centric approach when designing and implementing online learning experiences. The Tarbiyah & Teaching Science Faculty might utilize the knowledge acquired from this study to enhance their comprehension of their students' distinct requirements and inclinations. This comprehension can guide the creation of customized learning routes, more dynamic and captivating material, and more helpful and accessible student support. By prioritizing the student experience in its online learning strategy, the faculty can create a more inclusive and efficient educational environment that caters to all learning styles and demands.

Ultimately, the study offers a precise plan for the Tarbiyah & Teaching Science Faculty to improve its online learning environment by strategically investing in educational technology, consistently assessing quality, and prioritizing faculty development and student-centered learning. By focusing on improving the listed areas and adopting a proactive approach, the faculty can establish itself as a leader in online education. The Tarbiyah & Teaching Science Faculty's dedication to providing high-quality online education will not only meet but exceed the expectations of its students and instructors, serving as a benchmark for other schools to emulate and inspiring pride in its members.

6.4. Comparison analysis review

The study conducted at the Tarbiyah & Teaching Science Faculty across numerous Islamic State University campuses in Indonesia thoroughly analyzed the efficacy of online learning systems during the COVID-19 pandemic. This research was crucial, as educational institutions worldwide had to adjust to remote learning methods quickly. The study employed a systematic convenience sampling technique to collect data from 432 individuals, consisting of both students and professors, spanning various academic levels and locations. The demographic data showed an equal distribution of genders and a substantial majority of participants involved in e-learning for over a year, suggesting a solid familiarity with online learning platforms.

The study examined the data and discovered various crucial aspects contributing to online learning quality. The criteria of system quality, information quality, and service quality were crucial in determining user happiness and the overall success of the online learning experience. The findings underscored the significance of keeping content current, implementing strong security measures, and offering dependable technical assistance. Furthermore, the study highlighted the importance of the adaptability of online learning systems, particularly considering the swiftly evolving educational environment caused by the pandemic, which reassures the audience about their resilience in the face of challenges.

Moreover, the investigation uncovered that although the overall quality of the online learning systems was acceptable, specific areas necessitated enhancement, notably regarding service quality. The favorable comments on the system's reliability were juxtaposed with the requirement for improved responsiveness and support services. This discovery implies that to attain greater levels of user contentment, educational institutions must prioritize the ongoing enhancement of

their online learning platforms, with a particular emphasis on meeting the changing requirements of both students and instructors. This emphasis on user satisfaction should make the audience feel valued and integral to the learning process.

Ultimately, the research highlights the crucial significance of educational technology in influencing the trajectory of learning, especially in difficult situations like the COVID-19 epidemic. The study offers vital insights for educational institutions seeking to improve the effectiveness of their online learning systems by highlighting significant strengths and areas for growth. The results support the need for continued funding in educational technology and the creation of approaches that prioritize both the system's quality and the users' satisfaction. This will ensure that online learning remains a viable and effective form of education in the digital era.

6.5. The limitations of the research

It is important to acknowledge several limitations of this study that may have affected the results and conclusions. Firstly, the data collected through the questionnaire may be subject to response bias, where participants provide answers that they believe are socially desirable or expected. This bias could affect the validity of the findings, especially regarding the perception of system quality, information quality, and service quality.

Secondly, the study's reliance on self-reported data may introduce the potential for common method bias. This bias occurs when respondents provide consistent or biased responses due to the format or context of the survey. While efforts were made to mitigate this bias through validated instruments and anonymous responses, it is essential to recognize that some bias may still exist.

Additionally, the study's cross-sectional design limits the ability to establish causal relationships between variables. While structural equation modelling (SEM) allows for testing theoretical models, it cannot establish causality definitively. Longitudinal studies or experimental designs could provide more substantial evidence for causal relationships between educational technology implementation, system quality, information quality, service quality, and online learning quality.

Furthermore, the study's focus on a specific context, such as Islamic State University, may limit the generalizability of the findings to other institutions or settings. The unique characteristics and circumstances of Islamic State University may influence the results in ways that may not apply to other institutions.

Despite these limitations, this study contributes valuable insights into the factors influencing online learning quality. It provides actionable recommendations for improving the effectiveness and quality of online learning at Islamic State University. Future research could address these limitations by using more diverse data sources, longitudinal designs, and broader sample populations to enhance the generalizability and robustness of the findings.

7. Conclusion

This study emphasizes the significance of system, information, and service quality in facilitating effective online learning, especially in Islamic State universities in Indonesia during the COVID-19 epidemic. Employing a modified information system success model, the study reveals that the quality of teaching delivered by educators substantially improves student satisfaction and learning outcomes. This study underscores that while educational technology is crucial, instructors' proficiency in properly employing technology is as essential for fostering a significant learning experience. The study promotes the adoption of blended learning models that combine traditional and digital methods, enhancing the flexibility and resilience of education in confronting contemporary difficulties.

This research has specific shortcomings that warrant acknowledgement. The data, mainly gathered via self-reported questionnaires, may

be influenced by response bias, which could compromise the validity of the results, especially with perceived quality dimensions. The study's cross-sectional design restricts its capacity to determine causal links between factors, including system quality and learning outcomes. The emphasis on a singular institution (Islamic State University) may need to be revised to generalize the findings, as the results may only partially apply to other educational contexts.

Subsequent research should incorporate a more heterogeneous sample from diverse educational institutions to enhance these findings, hence increasing the generalizability and relevance of the results. A longitudinal methodology could be employed to assess causal links among system quality, information quality, service quality, and learning outcomes across time. Subsequent research may investigate the efficacy of various instructional methods in online and blended learning models, especially within diverse cultural and institutional contexts, thus improving the adaptability and significance of the findings across varied educational environments.

7.1. Recommendation

Education must evolve to meet the demands of the rapidly advancing era of Industry 4.0 and the emerging concept of Society 5.0, where technology plays a central role. Amidst the challenges posed by the COVID-19 pandemic, various online learning models have become integral to the education system, highlighting the importance of adapting to the digital landscape. This research holds significance in shaping the future of learning by providing insights into developing effective learning models supported by technological advancements. Given that online learning fundamentally alters traditional teaching practices, ensuring the readiness of e-learning systems and the quality of online instruction is crucial to avoid learning failures and meet student expectations.

To maintain educational continuity and enhance student satisfaction, the Tarbiyah & Teaching Science Faculty at Islamic State University and similar institutions must gauge student satisfaction with their learning experiences. Continuous evaluation and policy adjustments are necessary to foster the development of innovative blended learning models tailored to students' needs. Higher education institutions must remain adaptable, offering both synchronous and asynchronous learning options to maximize the benefits of successful student learning.

Furthermore, this study underscores the need for capacity-building initiatives such as seminars and training sessions to equip lecturers with innovative teaching techniques and alternative assessment methods suitable for online learning environments. By promoting effective online communication and ensuring the quality of information, systems, and services, educational institutions can optimize the online learning experience. Lecturers play a crucial role in fostering collaboration among students and guiding them through the learning process, emphasizing the importance of their active involvement in shaping the online learning environment.

Moreover, the findings of this research can inform the formulation of institutional e-learning policies aimed at enhancing learning design, providing support and assistance, and analyzing further areas for improvement. Additionally, these insights can guide government and university investment decisions, directing funds toward essential educational infrastructure necessary to thrive in the new normal of online education.

Actionable recommendations can be tailored to the specific context to enhance the effectiveness and quality of online learning at Islamic State University. Firstly, investing in improving the technical infrastructure of online learning platforms is essential. This includes ensuring reliability, accessibility, and scalability through regular maintenance, updates, and upgrades. Secondly, it is crucial to regularly review and update educational content to ensure its relevance, accuracy, and credibility. Incorporating real-world examples and case studies can enhance the practical applicability of the content.

Table 10
Results of the structural model

NO	Relationship	Path Coefficient	P values	f 2	VIF
1	Information Quality -> User Satisfaction	0.148	0.396	0.467	2.24
2	Information Quality -> Online Learning Quality	0.570	0.000	0.053	2.21
3	Information Quality -> Use Quality	-0.069	0.633	0.701	1.35
4	User Satisfaction -> Net Benefit	0.621	0.000	0.047	1.35
5	Online Learning Quality -> User Satisfaction	0.419	0.013	0.104	1.21
6	Online Learning Quality -> Use Quality	0.589	0.000	0.335	1.36
7	Online Learning Quality -> Net Benefit	0.348	0.000	0.12	1.52
8	Use quality -> User Satisfaction	0.232	0.138	0.002	1.25
9	Service Quality -> User Satisfaction	0.262	0.059	0.062	1.58
10	Service Quality -> Online Learning Quality	0.000	0.998	0.014	1.54
11	Service Quality -> Use Quality	0.232	0.038	0.467	2.24
12	System Quality -> User Satisfaction	-0.168	0.376	0.701	1.35
13	System Quality -> Online Learning Quality	0.308	0.040	0.335	1.58
14	System Quality -> Use Quality	0.195	0.136	0.053	1.54

Thirdly, strengthening support services and communication channels within the online learning environment is essential. Providing timely and effective technical support, counseling services, and academic advising can assist students and instructors as needed. Fourthly, fostering greater interactivity between students, instructors, and course content is critical. Utilizing discussion forums, virtual labs, and collaborative tools can promote engagement and knowledge retention.

Additionally, establishing mechanisms for providing feedback on student performance and the online learning experience is vital. Using automated quizzes, peer assessments, and surveys can help gather feedback and make improvements accordingly. Furthermore, flexible learning options, such as self-paced courses and asynchronous learning, can accommodate different learning styles and schedules. Ensuring that online learning resources and platforms are accessible to all students, including those with disabilities, is also crucial. Providing mobile compatibility and screen reader support can enhance inclusivity and reach. Lastly, incorporating various media formats, such as videos and simulations, into learning materials can enhance engagement and understanding (Table 10).

CRedit authorship contribution statement

Sutiah: Validation, Supervision, Project administration, Methodology, Data curation. **Supriyono:** Writing – review & editing, Writing – original draft, Validation, Methodology, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Sutiah reports financial support was provided by Maulana Malik Ibrahim Islamic State University Malang. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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