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INTEGRATING E-LEARNING INTO THE VOCATIONAL HIGH SCHOOL CURRICULUM: STRATEGIES, CHALLENGES, AND FUTURE DIRECTIONS

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Abstract

The study delves into E-learning integration in Vocational High School curricula, offering insights into strategies, challenges, and future directions. In the digital era, E-learning is crucial for enhancing vocational education. Utilizing a qualitative approach, the research involved in-depth interviews and participatory observation with 39 Vocational High Schools specializing in Computer and Network Engineering and Software Engineering. From this pool, 73 teachers and 195 students were sampled. Results revealed positive perceptions of integration, emphasizing benefits like improved understanding, increased interaction, resource accessibility, and engaging learning experiences. Teacher professional development is crucial, with ongoing training recommended. Triangulation of data confirmed that teacher participation positively influenced E-learning success. Despite challenges, optimistic attitudes highlight E-learning's potential for improving outcomes. The research advocates infrastructure development, comprehensive teacher training, curriculum refinement, and industry collaboration for successful integration, emphasizing continuous evaluation for a dynamic E-learning environment in Vocational High Schools.

Keywords: E-Learning Integration, Curriculum, Vocational High School, Strategies, Challenges, Future Directionss.

1. INTRODUCTION

E-learning has become an integral part of educational systems worldwide, offering numerous benefits in terms of flexibility, accessibility, and interactive learning experiences [1], [2]. In the context of Vocational High Schools, where practical skills and technical knowledge are the main focus, the integration of e-learning into the curriculum has significant potential [3]. This research specifically addresses the strategies, challenges, and future directions of integrating e-learning into the vocational high school curriculum [4]. The integration of e-learning into the curriculum provides opportunities to increase student engagement, encourage self-directed learning, and adapt to technological advances [5]. By integrating online modules, interactive tutorials, and virtual simulations, students can better understand concepts and gain hands-on experience in a virtual environment [6], [7].

However, this integration also poses certain challenges. Technical infrastructure requirements, teacher training, and resource allocation are key considerations in ensuring a successful e-learning implementation [8],[9]. Additionally, the design of online learning materials should align with the specific learning needs of vocational

high school students, incorporating real-world examples and industry-relevant scenarios [10]. Addressing these challenges requires the formulation of effective strategies. Collaborative partnerships between educational institutions, industry stakeholders, and technology providers can facilitate the development of tailored e-learning platforms and resources [11]. Teacher professional development programs can enhance educators' digital competencies and instructional design skills, enabling them to effectively facilitate e-learning experiences [12].

Looking to the future, the integration of e-learning into the vocational high school curriculum has enormous potential [13]. It can bridge the gap between theoretical knowledge and practical application, preparing students for the ever-evolving demands of the digital era [14]. The adoption of emerging technologies, such as augmented reality and virtual reality, can further enhance the learning experience and provide immersive, hands-on training opportunities [15].

In conclusion, the integration of e-learning into the vocational high school curriculum requires careful planning, collaborative efforts, and a student-cantered approach. By utilizing effective strategies, overcoming challenges, and embracing future directions, Vocational High Schools can provide students with comprehensive and dynamic learning experiences, preparing them for successful careers, particularly in the field of education in Vocational High Schools.

2. LITERATURE REVIEW

The integration of e-learning into the vocational high school curriculum has been the subject of numerous studies and research [16]. Scholars have explored various aspects related to e-learning integration, strategies employed, challenges faced, and future directions in this context [17]. This literature review provides an overview of the key findings and insights from previous research [18]. E-learning integration in Vocational High Schools has shown promise in enhancing students' learning experiences and outcomes [19]. Studies have highlighted the positive impact of e-learning on students' engagement, motivation, and knowledge acquisition [20]. The use of multimedia materials, interactive simulations, and virtual laboratories has effectively supported students' understanding of educational concepts in Vocational High Schools [21].

Strategies for successful e-learning integration have been identified in the literature [22]. Collaborative approaches involving teachers, industry professionals, and curriculum designers have been emphasized [23]. Involving industry partners can ensure that the curriculum is aligned with current industry practices and demands. Moreover, the integration of authentic and real-world scenarios into e-learning materials can enhance students' practical skills and readiness for the workforce [24], [25].

Challenges in e-learning integration have also been acknowledged. Technical infrastructure limitations, such as inadequate internet access or outdated hardware, can hinder effective e-learning implementation [26]. Teacher resistance and lack of digital literacy have been identified as significant barriers [27], [28]. Adequate teacher training and support are crucial to overcome these challenges and ensure effective utilization of e-learning tools and platforms [29].

The future directions of e-learning integration in Vocational High Schools hold great potential [30]. Research suggests the incorporation of mobile learning, gamification,

and adaptive learning technologies to enhance student engagement and personalization of learning experiences [31], [32]. The use of data analytics and learning analytics can provide insights into students' progress and inform instructional improvements. Additionally, the COVID-19 pandemic has further emphasized the importance of e-learning in ensuring the continuity of education [33]. Studies have explored the impact of the pandemic on e-learning adoption and identified strategies to address the challenges posed by remote learning [34].

In conclusion, the literature review highlights the positive impact of integrating e-learning into the vocational high school curriculum. The review emphasized the importance of collaborative strategies, discussed challenges related to infrastructure and teacher readiness, and discussed future directions for improving the e-learning experience. Findings from previous research provide valuable insights for policy makers, educators and stakeholders involved in e-learning integration in vocational education.

3. RESEARCH METHODOLOGY

Research Background

This research will use both quantitative [35] and qualitative research methods to gather comprehensive data and insights. The quantitative survey will provide numerical data regarding the level of e-learning integration, strategies used, and perceived challenges and benefits. Qualitative interviews and document analysis will provide in-depth insights into experiences, perspectives, and documentation related to e-learning integration. By combining quantitative and qualitative data collection and analysis, this study aims to provide a holistic understanding of e-learning integration, which includes strategies used, challenges faced, and future directions in Vocational High Schools in Padang. The mixed methods approach will allow for data triangulation, validation of findings, and a more comprehensive exploration of the research topic.

The research design illustrated in Figure 1 will enable researchers to investigate the research questions from multiple perspectives, provide detailed descriptions and explanations, and provide practical recommendations to improve the integration of e-learning in the curriculum at Vocational High Schools.

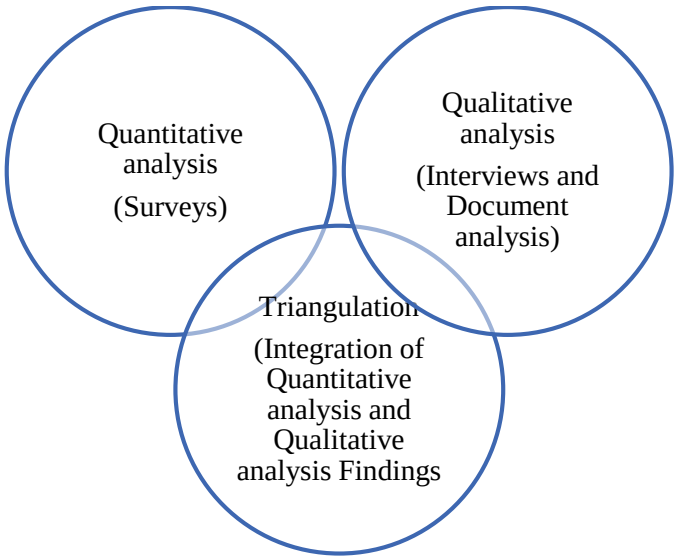

Figure 1: Mixed-methods triangulation study

Based on Figure 1, this study used a three-stage data analysis approach. At first, quantitative analysis was conducted on the questionnaire data using descriptive analysis. Next, qualitative analysis was applied to data derived from interviews and classroom observations, using thematic analysis. After quantitative and qualitative data analysis were conducted separately, integration was done through data triangulation. Triangulation was used to integrate and compare all data obtained from various sources, thus increasing the validity of the research findings.

Sample

This study employed the purposive sampling technique to identify the research sample, selecting students and teachers from Vocational High Schools in Padang that have integrated e-learning into their operating system curriculum. Specifically, the study focused on 39 Vocational High Schools specializing in Computer and Network Engineering and Software Engineering. From this pool of 39 schools, the researcher sampled 73 teachers and 195 students.

Instruments and Procedures

Data collected through interviews, surveys, and document analysis. Semi-structured interviews will be conducted with teachers, school administrators, and students to gather their perspectives on the strategies, challenges, and future directions of e-learning integration. Surveys will be administered to a larger sample of teachers and students to gather quantitative data on their experiences and perceptions of e-learning integration. Relevant documents such as curriculum materials, e-learning platforms, and assessment tools will be analysed to understand the strategies employed.

Indicators for interviews, surveys, and document analysis in the study on e-learning integration into the operating system curriculum of Vocational High Schools in Padang include [36]:

Table 1: Indicators for interviews, surveys, and document analysis in the study

Interviews	Surveys	Document analysis
1. Perceptions and experiences of teachers regarding e-learning integration 2. Challenges faced in implementing e-learning strategies. 3. Strategies employed for e-learning integration. 4. Perspectives on the Effectiveness of E-learning in enhancing learning outcomes. 5. Attitudes towards the future direction of e-learning in Vocational High Schools	1. Frequency and level of integration of e-learning in the curriculum in the classroom learning process. 2. Types of e-learning tools and resources used. 3. Teacher and student attitudes towards e-learning 4. Perceived Benefits and Challenges of e-learning integration 5. Training and professional development needs relating to e-learning	1. Curriculum documents and guidelines related to e-learning integration. 2. School policies and practices regarding e-learning 3. Reports and case studies on successful e-learning implementations 4. Assessment records and student performance data related to e-learning implementation.

These indicators will help capture a comprehensive understanding of e-learning integration, the strategies employed, the challenges faced, and the future directions in the operating system curriculum of Vocational High Schools in Padang. The data collected through interviews, surveys, and document analysis will provide valuable insights for analysing the current state of e-learning integration, identifying areas for

improvement, and proposing recommendations for enhancing e-learning practices in vocational education [37].

Table 2: Indicators for surveys in the study

Assessment	Indicator	No. Item
Frequency and level of integration of e-learning in the curriculum in the classroom learning process	1. E-learning Integration 2. Challenges in E-learning Integration 3. Future Directions	1,2,3 4,5,6 7,8,9
Types of e-learning tools and resources used	1. Learning Management Systems (LMS) 2. Online Modules and Tutorials 3. Multimedia Presentations 4. Discussion Forums and Collaboration Tools 5. Online Assessments and Quizzes:	10,11,12 13,14,15 16,17,18 19,20,21 22,23,24
Teacher and student attitudes towards e-learning	1. Perceived Benefits 2. Attitudes towards Technology 3. Motivation and Engagement 4. Future Adoption and Sustainability	25,26,27 28,29,30 31,32,33 34,35,36
Perceived benefits and challenges of e-learning integration	1. Improved Understanding 2. Flexibility and Accessibility 3. Real-World Relevance 4. Technical Issues 5. Digital Skills Gap 6. Lack of Personal Interaction	37,38,39 40,41,42, 43,44,45 46,47,48 49,50,51 52,53,54
Training and professional development needs related to e-learning	1. Teacher Competence 2. Professional Development Needs 3. Support and Resources	55,56,57 58,59,60 61,62,63

Descriptive analysis is employed to gather instrument data through the application of a Likert scale, which is subsequently transformed into quantitative data. The acquired data will undergo analysis utilizing descriptive statistics, employing the following formula:

$$NA = \frac{S}{M} \times 100\%$$

Description:

NA = Final score

S = Score obtained

SM = Maximum score

To assess the reliability of the questionnaire employed in the research concerning the integration of E-learning into the Operating System Curriculum at Vocational High Schools, specific criteria are outlined and presented in Table 3.

Table 3: E-learning questionnaire categories

No	Achievement level (%)	Category
1	85-100	Highly Effective
2	75-84	Effective
3	60-74	Moderately Effective
4	55-59	Less Effective
5	0-54	Not Effective

4. RESULT

Descriptive analysis

Descriptive data were obtained from survey results. Surveys are used to collect quantitative data about the extent of integration of e-learning into the operating system curriculum, strategies used, and perceived challenges and benefits. The survey instrument was finalized after expert evaluation and validation. The next phase includes a testing survey of the integration of e-learning into the operating system curriculum. 73 teachers and 195 students at vocational high school were selected and were given this survey to record their responses. This descriptive analysis contains the average value (mean), standard deviation (SD), range, variance, minimum score, and maximum score.

This descriptive analysis is used to explain the results of the questionnaire that has been filled out by teachers and students regarding the use of e-learning in operating system learning. The results of questionnaires from teachers and students are presented in Tables 1 and 2.

Table 4: Statistical analysis of the questionnaires filled out by teachers.

Assessment	M	SD	R	V	Min	Max
Frequency and level of integration of e-learning in the curriculum in the learning process	53,12	3,618	13	13	47	60
Types of e-learning tools and resources used	39,37	3,303	10	10,91	35	45
Teacher and student attitudes towards e-learning	67,03	4,425	17	19,58	58	75
Perceived Benefits and Challenges of e-learning integration	79,37	4,854	21	23,56	69	90
Training and professional development needs relating to e-learning	39,50	3,391	12	11,5	33	45

Table 5: Statistical analysis of the questionnaires filled out by teachers.

Assessment	M	SD	R	V	Min	Max
Frequency and level of integration of e-learning in the curriculum	40,08	2,624	10	6,886	35	45
Types of e-learning tools and resources used	66,30	4,057	19	16457	56	75
Teacher and student attitudes towards e-learning	53,25	2,876	13	8,272	47	60
Perceived Benefits and Challenges of e-learning integration	79,11	4,523	24	20,461	66	90
Training and professional development needs relating to e-learning	39,38	3,110	12	9,671	33	45

Based on the results of the table analysis above, the researcher then grouped each score obtained into the frequency distribution table and assigned the scores to several categories:

The first aspect relates to the frequency and level of integration of e-learning in the operating system curriculum, which is assessed by 3 indicators consisting of 9 statements. The statements in the first aspect revealed that 84.6% of teachers are in the sufficient category and 15.4% are in the good category in integrating e-learning into operating system learning. Meanwhile, from the student side, 91.8% of students were in the sufficient category and 8.21% were in the good category. The results indicated that e-learning had been integrated into learning activities. Most of the respondents agree that integrating e-learning into learning has its own challenges but

this integration will provide benefits and play an important role in building educational developments in the future.

The second aspect is regarding the type of e-learning tools and resources used which is assessed using 5 indicators consisting of 15 statements. The results of the questionnaire show that schools have used tools and resources in e-learning such as LMS, online modules, multimedia presentations, online quizzes, and so on. Of these tools, the tools most frequently used are multimedia presentations and discussion forums such as Zoom and WhatsApp groups.

The third aspect is related to teacher and student attitudes towards e-learning which was assessed with 4 indicators consisting of 12 statements. the results of the questionnaire showed that 88.5% of teachers and 95.4% of students were in the medium category, while 11.5% of teachers and 4.62% of students were in the high category related to attitudes in using e-learning in operating system learning. These results explain that most teachers and students feel that the integration of e-learning provides benefits for learning, and they have a positive attitude towards the use of e-learning. In addition, teachers and students have high enough motivation when using e-learning, while the rest sometimes still find it difficult when using e-learning it affects their motivation. Teachers and students think they will adopt and use e-learning for future learning.

The fourth aspect is an assessment related to the Perceived benefits and challenges of e-learning integration, which is assessed using 6 indicators consisting of 19 statements. The results of the questionnaire show that 97,4% of teachers and 97,9% of students are in the sufficient category, while 2,56% of teachers and 1,03% of students are in the sufficient category. However, there are 1% of students are in the less category. The results explain that most respondents feel that integrating e-learning can help increase their understanding and assist them in accessing learning flexibly. In addition, respondents feel that the use of e-learning is very relevant to the real world which is currently continuously developing following technological advances. However, apart from these benefits, integrating e-learning also has its own challenges, respondents sometimes experience technical problems when using e-learning. On the other hand, respondents feel they still have limited abilities in using e-learning, and they think that e-learning can reduce the level of direct interaction between individuals.

The last aspect regarding training and professional development needs to be related to e-learning which is assessed using 3 indicators consisting of 9 statements. The results of the questionnaires show that 76.9% of teachers are in the sufficient category and 23.1% of teachers are in the good category in terms of participating in training and professional development related to skills in implementing e-learning. Meanwhile, 84.6% of students considered that the teacher had sufficient competence in integrating e-learning into learning. The results explain that teacher competence greatly influences the effectiveness of using e-learning, therefore, there is a need for continuous professional development, especially regarding teacher competence in the field of e-learning. In addition, most of the respondents answered that the use of e-learning in learning really requires adequate resources and support from all elements of the school.

Interviews and Document Analysis

Interviews were conducted with teachers and students. The interviews were guided by instruments that had been prepared previously, namely regarding the strategies, challenges, and future directions of using e-learning in operating system learning in Vocational High Schools in Padang.

Based on the results of interviews with teachers and students regarding their perceptions and experiences in integrating e-learning into operating system learning, the following results are obtained: a) Learning becomes more interactive for teachers and students. Teachers see e-learning integration as an opportunity to make operating system learning more interactive and engaging for students. They can use multimedia, interactive simulations, or collaborative platforms to engage students in conceptual understanding and practical application of educational systems in Vocational High Schools. b) Ease of accessibility of learning resources. E-learning provides wider access to learning resources in the form of e-books, learning videos, online tutorials, or other digital resources. c) Increased Student Flexibility and Independence: With the integration of e-learning, teachers can provide opportunities for students to study independently and manage their own time. d) Engaging and Interactive Learning: The use of multimedia, videos, and interactive tools can help students understand concepts better and make learning more enjoyable.

In implementing e-learning for operating system learning, teachers employ various strategies, including a) Teachers utilize e-learning platforms to deliver classroom lessons, which generally consist of modules, videos, or quizzes. b) Carrying out online learning or discussions through various media such as Zoom, google meet, and WhatsApp groups. c) Provide online assignments (individual/group) that engage students, such as practical simulations using virtual software or working on small projects that involve all students in completing the final project. And d) the use of mobile applications made by the teachers themselves or other applications that are recommended.

The implementation of e-learning strategies in operating system learning does not always run smoothly, sometimes providing its own challenges for teachers and students., including a) facilities and accessibility, not all students have stable access to the internet or adequate devices to follow online learning. b) Technology Skills: Not all teachers and students have adequate technology skills to use e-learning platforms. c) E-learning may reduce face-to-face interaction between teachers and students. And d) online learning requires a high level of motivation and discipline from students.

But on the other hand, teachers and students consider that e-learning can provide effectiveness in improving operating system learning outcomes, among others: a) Learning activities become more flexible. b) Accessibility to learning resources becomes easier. c) E-learning can allow teachers to monitor and assess student progress more efficiently. d) Students are more actively involved in learning activities. In addition, teachers and students have positive attitudes towards the future direction of e-learning in Vocational High Schools, among others: a) Teachers can enthusiastically welcome the development of technology and the possibility of implementing e-learning in Vocational High Schools. b) Teachers appreciate the ease of delivering materials through e-learning platforms. c) Teachers can see e-learning to expand collaboration and cooperation networks with teachers in other schools,

industries, or other educational institutions. d) Students realize that e-learning can help prepare them to face the world of work.

For document analysis, researchers analysed several documents related to the integration of e-learning in operating system learning in Vocational High Schools, including a) school policy. This document includes the school's official policy related to the school's approach, objectives, and strategies for implementing e-learning in operating system learning. b) Lesson plan. This document includes details about the curriculum, syllabus, and learning objectives in a vocational high school. c) The analysis, of course, aims to get an overview of the extent to which e-learning has been implemented, including digital learning modules, video tutorials, online materials, and other digital resources used in classroom teaching. d) The e-learning guide, issued by the school, provides information on the use of e-learning in learning in Vocational High Schools. and e) Learning evaluation documents, such as portfolios of assignments, exams, or other assessments used in classroom learning, are conducted to understand how e-learning affects the evaluation process and provides benefits in measuring students' progress and understanding of the learning process in Vocational High Schools.

Triangulation

Triangulation was conducted to validate and strengthen the research findings. In the context of e-learning integration in operating system learning, triangulation is done by combining data from surveys, interviews, and document analysis.

The first step taken by the researcher was to conduct a survey to teachers and students related to e-learning integration in operating system learning. Then to strengthen the survey results, the researcher also conducted interviews with several teachers and students and then analysed the documents owned by the school related to the integration of e-learning. After the data from the survey results, interviews, and document analysis were collected, the researcher then compared the findings from the three data sources. The researcher analysed the similarities, differences, and contradictions in the data obtained so that it could help validate and produce stronger conclusions. Some of the results of the triangulation analysis are as follows:

The integration of e-learning in the curriculum at Vocational High Schools can run well, supported by the activeness of teachers in participating in training and professional development that focuses on e-learning implementation skills. Students also assess that their teachers have sufficient competence in integrating e-learning during learning. Teacher competence greatly influences the effectiveness of e-learning use, therefore there is a need for continuous professional development, especially regarding teacher competence in the field of e-learning. Respondents consider that the integration of e-learning provides benefits and plays an important role in building the development of education in the future, although it is inseparable from the challenges that must be faced. The integration of e-learning can also help students improve their understanding and assist them in accessing learning flexibly. In addition, respondents felt that the use of e-learning is very relevant to the real world which is currently constantly evolving following technological advances. It also provides more interactive learning between teachers and students, wider access to digital learning resources, increases students' independence, and makes it easier for teachers to monitor and assess students' progress more efficiently.

The use of e-learning can also increase students' and teachers' motivation in learning, although a small number of them still feel difficulties when using e-learning, such as experiencing technical constraints, limited abilities, and lack of facilities.

In learning, teachers usually use LMS, online modules, multimedia presentations, online quizzes, and so on. Teachers also utilize the e-learning platform to provide sub-lessons on classroom learning materials as well as conduct online discussions through various media, such as Zoom, Google Meet, and WhatsApp groups.

The integration of e-learning in the information system learning curriculum has been included in school documents, including school policy documents related to school goals and strategies in implementing e-learning in operating system learning, lesson plans made and used by teachers, e-learning guides, or modules, and learning evaluation documents such as assignment portfolios, exams, and other assessments.

Based on the findings of the research on integrating e-learning into the operating system curriculum in Vocational High Schools, some recommendations for future directions and improvements can be made. These recommendations aim to improve the effectiveness and efficiency of e-learning implementation and address the challenges identified in this study. Here are some of the recommendations:

Schools need to develop and ensure that they have adequate infrastructure, such as reliable internet connectivity, well-equipped computer labs, and access to modern online learning systems and software. This will create a conducive environment for e-learning and enable students to engage effectively with the curriculum.

Schools also need to provide comprehensive teacher training and support to integrate e-learning tools and strategies into the education curriculum in Vocational High Schools. This training should focus on instructional design, effective use of learning management systems (LMS), online assessment methods, and facilitating online discussions. Ongoing professional development opportunities and mentoring can also help teachers refine their e-learning skills.

Development of a well-structured and engaging curriculum is also required. This curriculum should be aligned with industry standards and emerging trends in current educational advancements. The curriculum should incorporate multimedia resources, interactive activities, and real-world case studies.

Consider collaborating with industry professionals to ensure the curriculum reflects current industry practices and requirements. Also, develop robust assessment methods that fit the nature of e-learning. Utilize different types of assessments, such as quizzes, simulations, and project-based assessments, to evaluate students' knowledge and skills.

The integration of e-learning in learning also needs to be evaluated and improved on an ongoing basis. Schools evaluate the effectiveness of e-learning by collecting feedback from students, teachers, and other stakeholders, and then the feedback is used to identify strengths, weaknesses, and areas for improvement. By implementing these recommendations, Vocational High Schools can improve the integration of e-learning into the curriculum, overcome challenges, and create an effective and engaging learning environment for students in vocational high schools.

5. CONCLUSIONS

The results of the research analysis regarding the integration of E-learning into the curriculum in Vocational High Schools have revealed significant insights regarding strategies, challenges, and potential future directions. This study underscores the importance of strategic planning in implementing E-learning initiatives to improve educational outcomes. The researcher analysed the results in several aspects, as follows: The first aspect relates to the frequency and level of e-learning integration in the operating system curriculum, which is assessed from 3 indicators consisting of 9 statements.

The statements in the first aspect revealed that 84.6% of teachers were in the moderate category and 15.4% were in the good category in integrating e-learning into operating system learning. While from the students' side, 91.8% of students were in the moderate category and 8.21% were in the good category. The results show that e-learning has been integrated into learning activities. Most respondents agree that integrating e-learning into learning has its own challenges, but this integration will provide benefits and play an important role in building the development of education in the future [38].

The second aspect is regarding the type of e-learning tools and resources used which is assessed using 5 indicators consisting of 15 statements. The questionnaire results show that schools have used tools and resources in e-learning such as LMS, online modules, multimedia presentations, online quizzes, and so on. Of these tools, the most frequently used tools are multimedia presentations and discussion forums such as Zoom and WhatsApp groups [39].

The third aspect is related to the attitude of teachers and students towards e-learning which is assessed by 4 indicators consisting of 12 statements. The questionnaire results show that 88.5% of teachers and 95.4% of students are in the medium category, while 11.5% of teachers and 4.62% of students are in the high category related to attitudes in using e-learning in operating system learning. This result explains that most teachers and students feel that e-learning integration provides benefits for learning, and they have a positive attitude towards using e-learning [40].

The fourth aspect is the assessment of Perceived benefits and challenges of e-learning integration, which is assessed using 6 indicators consisting of 19 statements. The questionnaire results show that 97.4% of teachers and 97.9% of students are in the moderate category, while 2.56% of teachers and 1.03% of students are in the fair category. However, there are 1% of students who are in the less category. The results explain that most respondents feel that integrating e-learning can help improve understanding and help them access learning flexibly [41].

The last aspect regarding training and professional development needs to be related to e-learning which is assessed using 3 indicators consisting of 9 statements. The results of the questionnaires show that 76.9% of teachers are in the sufficient category and 23.1% of teachers are in the good category in terms of participating in training and professional development related to skills in implementing e-learning. Meanwhile, 84.6% of students considered that the teacher had sufficient competence in integrating e-learning into learning.

The results explain that teacher competence greatly influences the effectiveness of using e-learning, Therefore, there is a need for continuous professional development, especially regarding teacher competence in the field of e-learning [42], [43]. The study found that teacher competence significantly influences the effectiveness of using e-learning, highlighting the need for continuous professional development, particularly in the field of e-learning. Interviews with teachers and students in Padang revealed that integrating e-learning in operating system learning in vocational high schools has several benefits, including increased interaction, accessibility of learning resources, increased student flexibility and independence, and engaging and interactive learning. Teachers use various strategies, such as using e-learning platforms, conducting online discussions, providing online assignments, and using mobile applications [44].

However, the implementation of e-learning strategies can be challenging due to factors such as facilities, technology skills, and face-to-face interaction. Despite these challenges, teachers and students believe that e-learning can improve operating system learning outcomes by making learning activities more flexible, making access to learning resources easier, allowing teachers to monitor and assess student progress more efficiently, and increasing student involvement in learning activities. Teachers and students also have positive attitudes towards the future direction of e-learning in Vocational High Schools, as they eagerly welcome technology development, appreciate the ease of delivering materials through e-learning platforms, and see e-learning to expand collaboration and cooperation networks [45].

Researchers analysed various documents related to e-learning integration in Vocational High Schools, including school policies, lesson plans, materials analysis, e-learning guidelines, and learning evaluation documents. Overall, e-learning can enhance the learning experience and prepare students for the world of work. The research on e-learning integration in operating system learning was conducted using triangulation, combining data from surveys, interviews, and document analysis. The results showed that the integration of e-learning in Vocational High Schools can be successful, with active participation from teachers in training and professional development [45]. Teacher competence is crucial for the effectiveness of e-learning use, and continuous professional development is necessary [46].

The integration of e-learning in the curriculum can improve students' understanding and accessibility of learning [47]. However, some students still face difficulties, such as technical constraints, limited abilities, and lack of facilities. Teachers typically use LMS, online modules, multimedia presentations, online quizzes, and other e-learning platforms [48]. School documents, such as policy documents, lesson plans, e-learning guides, and evaluation documents, also include the integration of e-learning in the information system learning curriculum. To improve the effectiveness and efficiency of e-learning implementation and address the challenges identified [49], schools should develop adequate infrastructure, provide comprehensive teacher training, develop well-structured and engaging curriculum development, and collaborate with industry professionals to ensure the curriculum reflects current practices and requirements [50]. Ongoing evaluation and improvement of e-learning in learning are essential to identify strengths, weaknesses, and areas for improvement. By implementing these recommendations, Vocational High Schools can enhance the integration of e-learning into the operating system curriculum, overcome challenges, and create an effective and engaging learning environment for students.

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