Development and Evaluation of an Interactive E-Module for Virtualization and Cloud Technology Learning in Computer Engineering Education

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ARTICLE INFO	ABSTRACT
	Background/Context: The transformation of learning in higher education requires the availability of structured and interactive digital teaching materials that support independent and practice-based learning. In the Virtualisation and Cloud Technology course, the limited availability of standardised learning modules has resulted in suboptimal learning processes and inconsistencies in students' learning outcomes. **Objective/Purpose:** his study aimed to develop an electronic module (e-module) for the Virtualisation and Cloud Technology course in the Computer Engineering Study Programme at Makassar State University to enhance learning effectiveness, conceptual understanding, and students practical skills.
	Method: This study employed a research and development approach using the 4D model, which consists of the define, design, develop, and disseminate stages. The e-module was validated by subject matter experts and media experts, followed by small-group and large-group trials. Its effectiveness was evaluated through pre-test and post-test assessments. **Results:** The validation results indicated that the e-module demonstrated very high quality in terms of content and media design. Student responses showed that the e-module was practical to use and supported the learning process. Furthermore, the implementation of the e-module significantly improved students' learning outcomes and promoted independent learning as well as deeper conceptual understanding. **Conclusion:** The developed Virtualisation and Cloud Technology e-module was found to be valid, practical, and effective as a digital learning resource. Its use contributes positively to improving learning outcomes and the overall quality of instruction, making it suitable for implementation in higher education, particularly in technology- and practice-oriented courses.

INTRUDOCTION

The transformation of learning in higher education requires the development of digital teaching materials that not only present content but also support independent, flexible, and competency-oriented learning, thereby encouraging lecturers and institutions to provide structured, easily accessible learning resources that meet the needs of students. Studies show that the quality of electronic teaching material design, systematic content structure, and integration of theory and practice have a significant effect on the effectiveness of digital learning in higher education (Al-Adwan et al., 2022; Sriwisathiyakun, 2023). And the use of digital modules has been proven to improve conceptual understanding, independent learning, and consistency in student learning outcomes compared to unstructured learning resources (Wen et al., 2022). In the context of higher education, the need for practical teaching materials is becoming increasingly crucial, especially in technical and cutting-edge technology-based courses that

require students not only to understand theoretical concepts, but also to be able to implement them in real-world contexts(Hou et al., 2023; Li et al., 2024). Systematically designed digital modules can bridge the gap between theory and practice and accommodate differences in students' learning speeds and styles, while the use of online learning resources that are not pedagogically curated and unstructured has the potential to reduce the effectiveness of independent learning and cause inconsistencies in student learning outcomes (Al-Adwan et al., 2022; Wang, 2024).

The Virtualisation and Cloud Technology course is a compulsory course in the Computer Engineering Study Programme at Makassar State University that requires mastery of abstract concepts and implementative skills related to virtualisation and cloud computing technologies. The dynamic, complex, and practice-based nature of the course demands teaching materials that are not only informative but also demonstrative and contextual, as studies show that digital modules incorporating simulations, case studies, and step-by-step practical guides can enhance students readiness to master cloud-based and virtualisation technologies. However, field findings from interviews with lecturers indicate that the course currently lacks a standard learning module, with instruction relying on materials from various unstructured online sources and limited lecturer capacity to provide integrated digital resources. This condition hinders students' independent learning due to the absence of systematically organised materials, aligning with research that shows the lack of standardised modules leads to inconsistent learning outcomes and increased student dependence on lecturers(Wang, 2024).

The development of e-modules containing comprehensive, valid, effective, and well-organised learning materials is required. These e-modules should not only present theoretical aspects of virtualisation and cloud technologies, but also include introductions to technological features, implementation guidelines, and contextual application examples. Practice-based digital modules designed using this approach are expected to support students' independent learning and align with course learning outcomes, as studies indicate that systematically designed e-modules can enhance learning effectiveness and students' readiness to master advanced technologies (Wang, 2024). However, most e-module development studies still focus on health sciences, general education, and basic practicums, while e-modules specifically designed for technology-related courses particularly virtualisation and cloud computing in educational contexts remain limited and rarely integrate independent, practice-based learning with industry case studies (Dermawan et al., 2025; Taylor et al., 2023). Although the presence of standardised modules has been shown to play an important role in ensuring consistency of learning outcomes and supporting independent learning in technical and practice-oriented courses, the development of such e-modules is still confined to certain fields and has not been widely applied to virtualisation and cloud technology courses (Nugroho et al., 2023; Mursyida et al., 2024; Dewi et al., 2025).

Based on this research gap, the development of e-modules on Virtualisation and Cloud Technology has become an academic and practical urgency. The uniqueness of the product developed in this study lies in the structured material arrangement, integration of theory and practice, presentation of virtualisation and cloud technology features, and the use of a research and development approach to produce e-modules that are valid, effective, and relevant to the needs of students in the Computer Engineering Study Programme. Thus, the development of this e-module is expected to support students' independent learning, improve conceptual understanding and practical skills, and enhance the quality of learning in the Virtualisation and Cloud Technology course.
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METHOD

This study utilised a research and development method, which aimed to produce and test the feasibility of a learning product (Sugiyono, 2019). The research stage focused on analysing user needs as the basis for product development, while the development stage was directed towards the design and development of e-modules as learning tools.

The research was conducted at the Department of Informatics and Computer Engineering, Faculty of Engineering, Makassar State University, located at Jalan Daeng Tata Raya, Parang Tambung, Makassar. The research was conducted over a period of three months, from June to August 2023.

The research subjects in the development of the e-module for the Virtualisation and Cloud Technology course in the Computer Engineering Study Programme at Makassar State University included students from the 2020 cohort who were currently enrolled in the course. A total of 30 students were involved as users to provide feedback on the developed e-module.

The development model used in this study is the 4D model proposed by Thiagarajan, (1974) which consists of four stages, namely define, design, development, and disseminate. This model was chosen because it provides a systematic and appropriate development process for producing valid and usable learning products.

RESULTS AND DISCUSSION

The outcome of this research and development study is an e-learning module specifically designed for the Virtualisation and Cloud Technology course. The development process was conducted in accordance with the 4D development model and commenced with the define stage.

At the define stage, an initial analysis was carried out to identify the existing conditions, factual issues, and learning problems encountered in the Virtualisation and Cloud Technology course. This analysis aimed to obtain a comprehensive understanding of instructional needs as a foundation for the development of the e-module. The initial analysis involved interviews with one of the lecturers responsible for teaching the Virtualisation and Cloud Technology course. Interviews were selected as the data collection method as they enable the acquisition of objective and accurate information regarding the learning process. In addition to interviews, analyses of student characteristics, learning concepts, relevant tasks, and learning objectives were also conducted. These steps were undertaken to gather comprehensive data to support the development of the e-module. The results of the define stage indicated the presence of learning-related issues that necessitated the development of an e-module for the Virtualisation and Cloud Technology course.

The subsequent stage was the design stage. At this stage, several activities were carried out, including the preparation of criterion-referenced tests, media selection, format selection, and module design. The preparation of criterion-referenced tests was conducted to systematically plan the instructional content to be presented in the e-module in accordance with the learning objectives. Content formulation was undertaken to identify the scope and level of detail of the material to be included. The selection of the module format and components was aligned with established principles of effective module development based on relevant theoretical frameworks. The draft e-module was then submitted for consultation with the academic supervisor to obtain feedback and recommendations for further refinement and improvement. Several examples of the designed Virtualisation and Cloud Technology e-module are presented in the following section:

a) Front Cover
   The front cover consists of the institution's logo, title, supporting images, institutional description and author's name, shown in Figure 1.
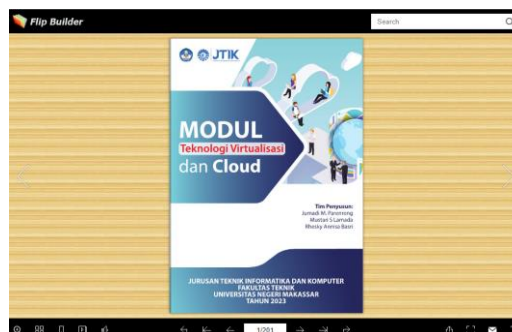

Figure 1 Front Cover

b) Layout of Material Description

The layout of the material in the e-module plays a very important role in facilitating effective learning and presenting information in a structured and easy-to-understand manner., shown in Figure 2.

Figure 2 Material Description Layout

c) Animation

Each time the user navigates to a page, the module will display an animation that resembles the process of opening a page, as shown in Figure 3.

Figure 3 Animation

d) Video

This e-module also contains introductory videos for each chapter related to the material presented, as shown in Figure 4.

Figure 4 Video introduction page

e) Assessment and Collection of Assignments

This e-module also includes an evaluation section at the end of each chapter consisting of quizzes and assignments, as well as a green button for submitting assignments. This is shown in Figure 5.
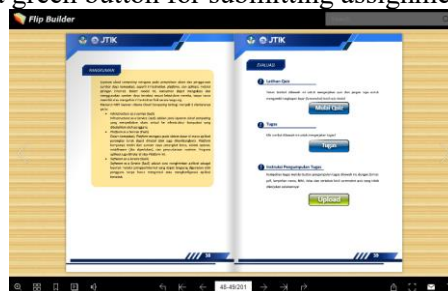
Figure 5 Evaluation Page

The development stage aims to produce a final product in the form of a module that has undergone a validation process. Validation is carried out by subject matter and media experts to identify deficiencies or weaknesses in the e-module. Subsequently, revisions are made to improve and refine the product. After the revision stage is complete, the e-module is tested by students. This trial aims to obtain student feedback and responses to the e-module for the Virtualisation and Cloud Technology course that has been developed. The data from the subject matter expert validation can be seen in Table 1 below:

Table 1 Results of Content Expert Validation

No.	Aspek	Skor Ahli Materi	Skor yang diharapkan	Persentase penilaian
1	*Self Instruction*	67	70	96%
2	*Self Contained*	10	10	100%
3	*Stand Alone*	10	10	100%
4	*Adaptive*	5	5	100%
5	*User Friendly*	9	10	90%
	Total Skor	**101**	**105**	**96%**
	Kategori : Sangat Layak			

Source: Data processing results

Based on the results of the study, the e-module on Virtualisation and Cloud Technology that has been developed is declared valid. The results of the research instrument validation include material validation and media validation. The material validation results show that the total score obtained is 101, and the expected score according to the number of statements in the questionnaire is 105, with a maximum score of 5 for each statement. Thus, the percentage of the total statement item score is 96% of the maximum percentage of 100%, which falls into the "Highly Valid" category. The data from the media expert validation can be seen in Table 2 below:

Table 2 Results of Media Expert Validation

No	Aspek	Skor Ahli Media		Jumlah Skor	Skor yang diharapkan
		Ahli Media Pertama	Ahli Media Kedua		
1	Format	20	18	38	40
2	Organisasi	37	37	74	80
3	Daya Tarik	78	74	152	160
4	Bentuk dan Ukuran Huruf	20	18	38	40
5	Ruang (Spasi Kosong)	9	9	18	20
6	Konsistensi	25	24	49	50
	Total Skor			369	390
	Presentase Penilaian			**95%**	
	Kategori: Sangat Layak				

Source: Data processing results

Based on the validation results of two media experts, a total score of 369 was obtained, with an expected score of 390. Therefore, the assessment percentage achieved was 95% of the maximum percentage of 100%, which also falls into the "Highly Valid" category.

The final stage of this research is dissemination. The dissemination of the e-module was carried out within a limited scope, namely to lecturers and the Computer Engineering Study Programme. After that, the researchers will review the results of the three problems that were previously identified. These results will discuss the e-module for the Virtualisation and Cloud Technology course in the Computer Engineering Study Programme, which has met the criteria of being valid, practical, and effective. The practicality of using the e-module was evaluated through an analysis of student responses. The Virtualisation and Cloud Technology e-module can be considered practical if the results of the student response questionnaire show significant results. The results of the research conducted by the researcher on students in the Computer Engineering Study Programme in the learning process show that the modules used are very helpful and provide convenience for students. This is reflected in the very positive responses given by students to the modules presented by the researcher. The data from the small group trial can be seen in Table 3 below:

Table 3 Small Group Trial Results

Responden	Aspek			Jumlah Skor	Skor *Max*	Presentase
	Materi	Media	Kemanfaatan			
R1	29	19	22	70	75	93,3%
R2	24	17	22	63	75	84,0%
R3	26	16	23	65	75	86,7%
R4	28	18	22	68	75	90,7%
R5	27	19	22	68	75	90,7%
R6	26	18	21	65	75	86,7%
R7	27	17	22	66	75	88,0%
Presentase Rata-Rata						**88,6%**
Kategori Penilaian : Sangat Praktis						

Source: Data processing results

Based on the data in Table 3, it can be seen that the assessment given by seven students had an average percentage of 88.6%, which can be categorised as "very practical". In addition, students who participated in small group trials also gave positive responses to the use of the Virtualisation and Cloud Technology e-module.

As a follow-up evaluation stage, a large-scale trial was conducted to assess the practicality and effectiveness of using the Virtualisation and Cloud Technology e-module based on student responses. The data from the large-scale trial can be seen in Table 4 below:

Table 4 Results of the Large-Scale Tria

Responden	Aspek			Jumlah Skor	Skor Max	Persentase
	Materi	Media	Kemanfaatan			
R1	29	20	25	74	75	98,7%
R2	30	20	25	75	75	100,0%
R3	29	19	23	71	75	94,7%
R4	26	20	25	71	75	94,7%
R5	25	20	25	70	75	93,3%
R6	30	20	25	75	75	100,0%
R7	29	20	25	74	75	98,7%
R8	28	20	25	73	75	97,3%
R9	29	20	25	74	75	98,7%
R10	23	17	22	62	75	82,7%
R11	24	16	20	60	75	80,0%
R12	30	20	25	75	75	100,0%
R13	30	20	25	75	75	100,0%
R14	25	20	25	70	75	93,3%
R15	29	20	25	74	75	98,7%
R16	29	20	25	74	75	98,7%
R17	24	17	19	60	75	80,0%
R18	30	20	25	75	75	100,0%
R19	16	10	11	37	75	49,3%
R20	27	17	24	68	75	90,7%
R21	24	16	20	60	75	80,0%
R22	28	19	24	71	75	94,7%
R23	28	20	25	73	75	97,3%
R24	27	20	22	69	75	92,0%
R25	25	20	25	70	75	93,3%
Presentase Rata-Rata						**85,3%**
Kategori Penilaian: Sangat Praktis						

Source: Data processing results

From the data presented in Table 4, it can be seen that the assessment results given by 25 respondents had an average percentage of around 85.3%, which can be categorised as "very practical". In addition, students involved in trials in large groups also gave positive responses to the use of the Virtualisation and Cloud Technology e-module.

As part of the evaluation of the effectiveness of the developed e-module, pre-tests and post-tests were conducted to measure changes in student learning outcomes. The results are presented in Table 5 below:

Table 5 Post-Test and Pre-Test Results

Hasil Test	Nilai Awal	Nilai Setelah Penerapan E-modul	Rata-Rata
Nilai Tertinggi	80	100	90
Nilai Terendah	30	50	40
Nilai Rata-Rata(%)	57%	87%	72%
Tuntas	6	28	17
Tidak Tuntas	26	4	15
Ketuntasan Klasial (%)	19%	88%	54%

Source: Data processing results

From the data shown in Table 5 above, it can be concluded that, prior to the implementation of the Virtualisation and Cloud Technology e-module, there was variation in student scores. The highest score obtained was 80, while the lowest score was 30, with an overall average score of 57%. Out of a total of 32 students, only 6 students achieved a passing grade, while the remaining 26 students did not achieve a passing grade.

The results of the study indicate that the implementation of e-modules for the Virtualisation and Cloud Technology course has a significant impact on improving student learning outcomes. The highest score achieved by students was 100 and the lowest was 50, with an average learning outcome of 87%. Of the total 32 students, 28 students (88%) achieved learning completeness, while only 4 students did not meet the completeness criteria. This classical completeness percentage is in the very good category, indicating that the developed e-module is effective in supporting the learning processThe results of the study indicate that the use of e-modules has a very positive impact on students, as reflected in a significant improvement in student learning outcomes. This can be verified through the data in the research table, which shows that the average level of student learning outcomes is in the very good category. Thus, e-modules in the Virtualisation and Cloud Technology course have proven to be effective in improving student learning outcomes. This finding is in line with various studies that state that the use of interactive, systematic, and easily accessible e-modules supports independent learning according to individual needs. In addition, e-module-based learning has been proven to be valid, practical, and effective in improving conceptual understanding, learning outcomes, student engagement, and the transfer of knowledge from theory to practice (Wibowo et al., 2024; Oksila et al., 2025).

The findings of this study reinforce that the use of e-modules in higher education can improve student learning outcomes, engagement, and independent learning. E-modules that are systematically designed and interactive have been proven effective in improving conceptual understanding, interest in learning, and flexibility of learning according to individual needs(Eliyasni et al., 2021; Sanova et al., 2022). In addition, digital learning also has a positive impact on learning behaviour, student engagement, and understanding of complex concepts through independent and repeated learning (Basu et al., 2022; Koth et al., 2021). These findings are in line with literature reviews stating that the use of digital learning technology in higher education contributes positively to student engagement and learning processes (Pinto & Leite, 2020).

Overall, the findings demonstrate that the systematically designed e-module effectively enhances students' learning outcomes, engagement, and independent learning in the Virtualisation and Cloud Technology course. The integration of structured content, interactive elements, and practice-based activities appears to play a crucial role in bridging the gap between theoretical understanding and practical application. These results suggest that well-developed digital learning resources can serve as a viable solution to address the challenges of teaching complex and technology-oriented subjects in higher education. However, this study was conducted within a limited context and involved a relatively small sample size, which may affect the generalisability of the findings. Future research is recommended to explore the long-term impact of e-modules, their integration with learning management systems, and their application across different technological disciplines to further enhance digital learning effectiveness.

CONCLUSIONS

Based on the results of the study, it can be concluded that the design of the E-module on Virtualisation and Cloud Technology for the Computer Engineering Study Programme at Universitas Negeri Makassar has met the criteria of validity, practicality, and effectiveness. The level of validity of the e-module falls into the very valid category, as indicated by the material expert assessment score of 96% and the media expert assessment score of 95%. In addition, the level of practicality of the e-module is categorised as very practical, based on student responses with a percentage of 85.3%. In terms of effectiveness, the evaluation of learning outcomes through pre-test and post-test results shows that the students' classical mastery level reached 88%, which is classified as very good. These findings indicate that the use of the e-module has a significant positive impact on improving students' learning outcomes.

Based on these achievements, it is recommended that lecturers consider using the E-module on Virtualisation and Cloud Technology as an alternative teaching material in the learning process within the Computer Engineering Study Programme. Students are expected to optimise the use of this e-module effectively to enhance their understanding of the material and reduce learning fatigue. Furthermore, the institution may take this e-module into consideration in formulating policies for the development of learning innovations that align with students' needs and potential. For future researchers, the E-module on Virtualisation and Cloud Technology can be further improved in terms of content and interface, and may also be utilised as a reference, source of inspiration, and benchmark for the development of more engaging and innovative e-modules.

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