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Research Article

DEVELOPMENT OF DISTANCE LEARNING STRATEGIES BASED ON LEARNING MANAGEMENT SYSTEMS TO IMPROVE SELF-DIRECTED LEARNING AND STUDENTS' UNDERSTANDING OF CONCEPTS

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Abstract
Advances in information technology have significantly changed higher education, particularly through the implementation of distance learning. However, challenges remain, including low levels of student self-directed learning and inadequate conceptual understanding. This study aims to develop an LMS-based distance learning strategy in the form of digital learning modules that are valid, practical, and effective in improving student self-directed learning and conceptual understanding. This study uses a research and development (R&D) approach with Dick and Carey's instructional design model. Product validity was evaluated through expert validation, with results of 91% from subject matter experts, 80% from media experts, and 100% from learning design experts, indicating that the product is feasible for implementation. The usefulness and effectiveness were evaluated through small and large group trials and N-Gain analysis. The results of the independent learning questionnaire increased from 83% in the small group trial (practical category) to 97% in the large group trial (very practical category), indicating the high usefulness of the developed product. Additionally, N-Gain analysis showed a significant increase in students' conceptual understanding between pre- and post-tests. These findings indicate that LMS-based distance learning strategies effectively enhance students' self-directed learning and conceptual understanding.

Keywords: Distance Learning, Instructional Strategy, Learning Management System, Self Directed Learning, Conceptual Understanding

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INTRODUCTION

In recent years, higher education systems have undergone significant transformation as a result of advances in information technology and global situations such as the COVID-19 pandemic. These changes have prompted educational institutions to adopt distance learning as a primary alternative to face-to-face instruction. Although distance learning offers flexibility in the learning process, it also presents distinct challenges, particularly related to students' motivation, self-directed learning, and learning outcomes.

Students are required to possess strong self-directed learning skills, namely the ability to organize, implement, and evaluate their own learning processes, in order to participate effectively in distance learning. However, not all students are adequately prepared or equipped with appropriate strategies for independent learning. This condition can affect students' ability to learn and understand concepts, especially in courses that require critical thinking and deep conceptual understanding. Several studies have reported that students who lack optimal autonomy in online learning environments tend to demonstrate decreased interaction, active engagement, and comprehension of learning materials. Therefore, investigating the relationship between students' conceptual understanding and self-directed learning in the context of distance learning is crucial for the development of more flexible and effective instructional approaches.

Since the COVID-19 pandemic, distance learning has emerged as one of the main solutions in higher education. Both instructors and students have faced numerous challenges due to the sudden transition from face-to-face instruction to online learning. One critical issue revealed during this transition is that many students were not adequately prepared for learning processes that require a high level of independence. Self-directed learning, defined as the ability to regulate, monitor, and evaluate one's own learning process, is a prerequisite for effective distance learning. Unfortunately, many students lack sufficient intrinsic motivation and advanced learning tools, which hinders their ability to deeply understand course content and often leads to decreased learning outcomes (Rachmawati, 2010).

In addition, technical constraints such as unstable internet connections and limited access to digital devices remain critical challenges that significantly reduce the effectiveness of distance learning. These conditions reflect a broader phenomenon of socio-technical disconnection, in which structural inequalities in technological access intersect with students' socio-economic backgrounds. In rural contexts, unstable and intermittent connectivity restricts continuous access to learning resources, particularly those requiring high bandwidth, thereby widening the digital divide. Recent studies highlight that limited infrastructure and poor connectivity remain key barriers to effective online learning participation (Karim et al., 2025) .

Furthermore, emerging research on bandwidth-efficient pedagogy emphasizes the importance of low-data instructional design in under-connected regions. For instance, the use of low-bandwidth digital systems and adaptive content delivery has been shown to mitigate learning disruptions caused by unstable networks while improving student engagement and persistence (Lutfullayeva et al., 2025) . Similarly, contextualized digital learning models in rural education demonstrate that limited connectivity and device constraints require pedagogical strategies that prioritize accessibility and sustainability (Serrano-Ardila et al., 2026) . Without such adaptive approaches, students' opportunities to actively engage in learning activities and develop self-directed learning skills are significantly constrained.

Furthermore, interaction between students and instructors, as well as among students themselves, tends to decrease in asynchronous online learning environments. This reduction in social presence, when combined with conditions of socio-technical disconnection, may intensify students' sense of isolation and reduce learning motivation. As a result, students often experience difficulties in comprehending course materials and maintaining consistent engagement. The lack of stable connectivity not only disrupts access to instructional content but also limits opportunities for meaningful interaction and timely feedback, which are

essential for both cognitive and affective learning development. Therefore, pedagogical designs that integrate bandwidth-efficient strategies and socio-emotional support mechanisms are crucial to addressing the compounded challenges of socio-technical dependence in distance learning contexts.

At present, there is a lack of research examining the direct relationship between self-directed learning (SDL) and students' conceptual understanding in fully online learning contexts, despite the increasing implementation of distance learning in higher education. Although a study by Lee et al. (2019) demonstrated that self-directed learning can enhance cognitive presence in blended learning environments, limited research has explicitly investigated the impact of SDL on students' conceptual understanding in fully online learning settings. This gap indicates the need for further investigation, particularly to determine the extent to which students' self-directed learning can enhance conceptual understanding in fully online environments. Moreover, although SDL has been recognized as a crucial competency in 21st-century education, specific methods for effectively developing SDL in online learning environments have not been clearly explained in the literature. According to Chen and Saharuddin (2024), many students still experience difficulties in managing self-directed learning, including limited awareness of the importance of SDL, constraints in utilizing digital learning resources, and insufficient instructional support from instructors to promote independent learning. Therefore, further research is needed to identify appropriate strategies to enhance the effectiveness of SDL in distance learning.

Furthermore, students' technological readiness is another factor that potentially influences the success of SDL, yet it has not been extensively examined in relation to conceptual understanding. Lee et al. (2019) noted that students' digital readiness affects the effectiveness of blended learning; however, its role in fully online learning particularly regarding SDL and conceptual understanding remains underexplored. Zhao et al. (2023) also reported that course design and instructional strategies significantly influence satisfaction and effectiveness in online learning. Nevertheless, studies that specifically focus on the impact of instructional design on SDL effectiveness and conceptual understanding outcomes remain limited, especially in higher education. In addition, drastic changes in learning environments during the COVID-19 pandemic have influenced students' motivation and engagement. Almomani et al. (2023) reported a decline in student engagement in online learning, which may negatively affect students' self-directed learning abilities and conceptual understanding. However, research examining the long-term effects of reduced motivation on SDL and conceptual knowledge in sustained distance learning environments is still limited.

This study offers novelty through the development of an LMS-based digital learning module specifically designed to facilitate distance learning, with the primary goal of improving students' self-directed learning and conceptual understanding. Unlike previous studies that focused mainly on the general effectiveness of LMS platforms or learning modules, this study integrates a self-directed instructional design approach with a modular learning structure that can be flexibly accessed through an LMS. Another novelty lies in the application of a design-based research approach to develop a digital learning module that is not only adaptive to learners' characteristics in distance learning contexts, but also emphasizes digital scaffolding, self-reflection, and structured formative evaluation embedded directly within the module content. In addition to providing learning resources, the module actively supports the development of students' metacognitive skills, which are fundamental to self-directed learning.

This study also addresses a research gap by exploring the integration of LMS-based digital modules with both qualitative and quantitative indicators of conceptual understanding improvement in online learning environments. In other words, this research contributes to the development of a digital learning strategy that functions not only as a medium for content delivery but also as a pedagogical intervention strategically designed to foster sustained self-directed learning and conceptual understanding in higher education.

To address the problem of low self-directed learning and conceptual understanding among students in distance learning contexts, this study proposes a solution through the development of an interactive digital learning module systematically designed using an LMS-based distance learning strategy. The module is designed not merely as a content delivery medium, but also as a learning tool that guides students toward becoming self-directed learners through features that support goal setting, self-reflection, automated feedback, and integrated formative assessment.

Based on instructional design principles and the philosophy of self-directed learning, the digital learning module incorporates instructional content delivered through multiple media formats, including text, interactive videos, simulations, and adaptive quizzes. In accordance with the characteristics of distance learning, this approach aims to provide a structured yet flexible learning environment in which students are free to determine their learning schedules, strategies, and pace. Through the use of an LMS, students can easily access learning resources anytime and anywhere while receiving immediate feedback. By integrating contextual and problem-based content with reflective exercises, this development is expected to enhance students' ability to manage their own learning processes while deepening their conceptual understanding. Therefore, the findings of this study are relevant in addressing the challenges of 21st-century learning, particularly in higher education contexts that emphasize autonomy, flexibility, and deep conceptual mastery in digital learning environments.

RESEARCH METHOD

This study employed a Research and Development (R&D) approach as a form of pedagogical product engineering aimed at systematically designing, developing, and refining an LMS-based digital learning module to support distance learning. The primary objective of this research was to enhance students' Self-Directed Learning (SDL) and conceptual understanding within a fully online learning environment.

The R&D approach was selected due to its emphasis on iterative design and formative evaluation, which distinguishes scientific development research from conventional software development practices. The development process involved multiple iterative cycles consisting of design, testing, feedback collection, and refinement. This approach is consistent with recent studies indicating that iterative design enables continuous improvement of digital learning modules through user-centered feedback, thereby enhancing usability and pedagogical effectiveness (Herlandy & Syahfutra, 2025) .

In addition, iterative development models in educational contexts have been shown to systematically integrate evaluation results from each phase into subsequent design improvements, ensuring that the product evolves in alignment with learner needs and instructional goals (Jaakma & Kiviluoma, 2026) . Similarly, LMS-based module development using iterative incremental approaches has demonstrated strong initial validity in terms of content and system design, while emphasizing the need for continuous testing to ensure practicality in real learning environments (Novita et al., 2025) .

Through this structured and iterative process, each development cycle contributed to improving both the instructional quality and functional usability of the module. Therefore, the resulting product is expected to meet established standards of validity and practicality, while also being adaptable to real-world distance learning conditions.

Research Design

This study The research design was based on the Dick and Carey instructional design model, which emphasizes the systematic alignment between learning objectives, instructional strategies, learning materials, media, and assessment. This model was chosen because it supports the development of comprehensive instructional systems suitable for distance learning

environments. The development process included needs analysis, instructional design, material development, formative evaluation, product revision, and implementation within a Learning Management System (LMS).

Research Target/Subject

The research subjects consisted of undergraduate students in higher education who participated in distance learning courses delivered through an LMS. The participants were involved in small-group and large-group trials to evaluate the practicality and effectiveness of the developed digital learning module. In addition, expert validators including subject matter experts, media experts, and instructional design experts were involved to assess the validity of the product.

Research Procedure

Procedures The research procedure followed the stages of the Dick and Carey model, which can be summarized as follows:

1. Needs Analysis, to identify problems related to low self-directed learning and conceptual understanding in distance learning.
2. Instructional Analysis, to determine learning objectives and required competencies.
3. Learner and Context Analysis, to identify students' characteristics and learning conditions in online environments.
4. Instructional Design, including the development of learning strategies, content structure, and assessment plans.
5. Development of Digital Learning Module, integrating multimedia content, formative assessments, and self-directed learning features within the LMS.
6. Formative Evaluation, conducted through expert validation and limited trials.
7. Revision, based on feedback from experts and trial results.
8. Implementation, through small-group and large-group trials.
9. Evaluation, to assess practicality and effectiveness of the product.

Instruments, and Data Collection Techniques

Data were collected using several instruments, including:

1. Validation Sheets, used by subject matter experts, media experts, and instructional design experts to assess the validity of the developed module.
2. Self-Directed Learning Questionnaire, used to measure students' perceptions of learning independence and product practicality during small-group and large-group trials.
3. Conceptual Understanding Test, administered as pre-test and post-test to evaluate learning effectiveness.
4. Documentation, used to support data related to the development and implementation process.

Data collection techniques included expert judgment, questionnaire administration, and achievement testing conducted through the LMS.

Data Analysis Technique

Data analysis was conducted using both quantitative and descriptive approaches.

1. Validation data were analyzed using percentage scores to determine product feasibility based on expert assessments.
2. Questionnaire data were analyzed descriptively by calculating percentage scores to determine the practicality level of the developed module.
3. Learning effectiveness was analyzed using the Normalized Gain (N-Gain) formula to measure improvements in students' conceptual understanding between pre-test and post-test results. The results of the analysis were interpreted using predetermined

criteria to categorize validity, practicality, and effectiveness of the developed learning module.

RESULTS AND DISCUSSION

The results of this study were obtained through expert validation, small group trials, large group trials, and product effectiveness analysis using N-Gain calculations. The product developed is a digital learning module based on a Learning Management System (LMS) with a distance learning strategy designed to improve Self-Directed Learning (SDL) and students' understanding of concepts.

1. Validation Results
   a. Subject Matter Expert Validation

Material validation was conducted by a subject matter expert to assess the feasibility of the developed instructional module, particularly in terms of the alignment of content with learning objectives, the quality and accuracy of the material, support for self-directed learning, the potential to enhance students' conceptual understanding, as well as the design and presentation of the module within the context of Learning Management System (LMS)-based implementation. The material validation in the development of the LMS-based distance learning strategy aimed at improving students' self-directed learning and conceptual understanding was conducted by Prof. Dr. Nurhikmah, S.Pd., M.Si., a lecturer in the E-learning course in the Educational Technology Study Program, Faculty of Education, Universitas Negeri Makassar, who served as the material expert validator. The results of the material validation are presented in Table 1. as follows:

Table 1. Material Validation Results

Aspect	Assessment Points	Validation Score
Alignment of Materials with Learning Objectives	1. Learning outcomes are clearly and measurably formulated.	5
	2. The module content aligns with the intended learning outcomes.	4
	3. The content is organized systematically and logically.	5
	4. The subtopics within the module are coherent and interconnected.	4
Quality and Accuracy of Materials	5. The content is derived from relevant and up-to-date references.	5
	6. There are no conceptual, data-related, or terminological errors in the content.	5
	7. The language used in the module is clear and easy to understand.	4
	8. The content is free from bias or misleading information.	4
Support	9. The material provides guidance that	5

for Self Directed Learning	encourages students' self-directed learning.	
	10. The module includes activities/tasks that stimulate students to plan and evaluate their learning.	4
	11. The material offers alternative learning resources or learning pathways.	5
	12. The module facilitates students' self-reflection throughout the learning process.	5
Ability to Improve Understanding of Concepts	13. The content is supported by contextual examples that clarify concepts.	5
	14. The module is equipped with practice exercises or concept application tasks.	4
	15. The assessments in the module are appropriate for measuring students' conceptual understanding.	4
Module Design and Presentation	16. The module format is consistent, well-structured, and easy to navigate.	5
	17. The module is designed to be responsive for use within a Learning Management System (LMS).	4
	18. The visual design supports readability and enhances learning interest.	5
Mean		**82**

Table 1 presents the results of the subject matter expert validation of the instructional content included in the developed learning module. Based on the data presented in Table 1, the percentage score of the validity level was calculated in accordance with the criteria proposed by Arikunto (2010), as described below:

$$Percentage = \frac{Answer}{N\ X\ Highest\ Weight} X\ 100\%$$

$$Percentage = \frac{82}{18\ X\ 5} X\ 100\% = 91\%$$

After being converted using the conversion table, the percentage score of 91% falls into the very good qualification. However, the product was recommended for trial implementation with revisions based on the suggestions and comments provided by the subject matter expert regarding the instructional module, in order to further improve the quality of the developed product.

b. Media Expert Validation

Media validation was conducted to assess the feasibility of the instructional media used in the developed learning module and its implementation within a Learning Management System (LMS) environment. This validation aimed to ensure that the learning module met the principles of digital learning media design, including visual appearance, navigation, LMS compatibility, accessibility, and media functionality,

prior to proceeding to the field trial stage. The media validation in this study was carried out by Dr. Muhibuddin, M.Pd., a lecturer in the Educational Technology Study Program, Faculty of Education, Universitas Negeri Malang, who possesses expertise in the field of learning facilitation and served as the media expert validator. The results of the media validation are presented in Table 2. as follows:

Table 2. Media Validation Results

Aspect	Assessment Points	Validation Score
Visual Appearance and Design Aspects	1. The media interface is attractive and appropriate to students' characteristics.	4
	2. The layout is consistent and easy to understand.	4
	3. The use of colors, icons, and visual elements supports readability.	4
	4. The visual design helps maintain focus on the main content.	3
Navigation and Interactivity Aspects	5. Navigation within the module is easy to use and not confusing.	4
	6. Interactive features (quizzes, discussions, feedback) function properly.	4
	7. The module allows students to explore the content independently.	4
	8. Access to each section of the module/page logic functions properly.	5
Media Compatibility with Learning Management Systems	9. The media operates properly on the Learning Management System (LMS) platform used.	5
	10. Media features are well integrated with LMS functions such as forums, quizzes, and assessments.	4
	11. The module is easily accessible across various devices (PCs, tablets, and smartphones).	4
	12. Page/module loading time is efficient and does not disrupt learning.	4
Accessibility and Usability Aspects	13. The media is easily accessible for students with diverse levels of technological proficiency.	4
	14. The module can be used flexibly according to students' learning schedules.	4

	15. Text, images, and audiovisual media are understandable for all students.	3
	16. The module provides clear usage guidelines to help students utilize the module effectively.	4
Functionality and Consistency Aspects	17. All links and media features function properly.	4
	18. No technical errors are found during module usage.	4
	19. The module is free from outdated content, errors, or confusing visuals.	4
	20. Media formats and elements are consistent throughout all sections of the module.	4
Mean		**80**

Table 2. presents the results of the media expert validation of the developed instructional media in the form of a learning module. Based on the data presented in Table 2., the percentage score of the media validity level was calculated according to the criteria proposed by Arikunto (2010), as described below:

$$Percentage = \frac{Answer}{N\ X\ Highest\ Weight} X\ 100\%$$

$$Percentage = \frac{80}{20\ X\ 5} X\ 100\% = 80\%$$

After being converted using the conversion table, the percentage score of 80% falls into the good qualification. However, the product was recommended for trial implementation with revisions based on the suggestions and comments provided by the media expert regarding the instructional module, in order to improve the quality of the developed product.

c. Learning Design Expert Validation

Instructional design validation was conducted to assess the feasibility of the instructional design that served as the foundation for the development of the learning module prior to its implementation in the learning process. This validation aimed to ensure that the developed instructional design was aligned with the learning objectives, learner characteristics, and principles of effective instruction, particularly within the context of Learning Management System (LMS)-based learning. The instructional design validation in this study was conducted by Dr. Fikri Aulia, M.Pd., a lecturer in the Educational Technology Study Program, Faculty of Education, Universitas Negeri Malang, who has expertise in the fields of curriculum and instruction and served as the instructional design expert validator. The results of the instructional design validation are presented in Table 3. as follows:

Table 3. Learning Design Validation Results

Aspect	Assessment Points	Validation Score
Goal Analysis	1. Learning objectives are formulated clearly,	5

Learning	specifically, and measurably.	
	2. Learning objectives are aligned with students' needs and the course requirements.	5
	3. The objectives have been analyzed based on students' needs and characteristics.	5
Analysis Learners and Context	4. The instructional design considers students' initial characteristics (prior knowledge, skills, and motivation).	5
	5. The learning context (technology, LMS access, time flexibility) has been considered in the design.	5
Task Analysis and Instructional Analysis Instructional Analysis	6. The instructional design includes an analysis of the competencies that students must achieve.	5
	7. Instructional analysis is conducted logically and in depth in accordance with the objectives.	5
	8. The learning structure (module flow) is organized based on a rational sequence of competencies.	5
Development Objectives Behavior & Instruments Evaluation	9. Behavioral objectives (learning objectives) reflect the expected learning outcomes.	5
	10. Evaluation instruments (quizzes, assignments, discussions, etc.) are aligned with the learning objectives.	5
	11. The evaluation is designed to measure the achievement of conceptual understanding and self-directed learning skills.	5
Learning Strategies	12. The learning strategy encourages students' active and independent engagement.	5
	13. The strategy facilitates distance learning through the Learning Management System (LMS).	5
	14. The strategy aligns with the principles of self-directed learning–based instruction.	5
Development of Teaching Materials and Media	15. The learning materials are designed to be engaging, interactive, and suited to students' needs.	5
	16. The media used supports conceptual	5

	understanding in a visual and contextual manner.	
	17. The LMS is optimally utilized in the presentation of learning materials.	5
Implementation and Evaluation Formative	18. The planning for learning implementation is clearly described.	5
	19. A formative evaluation and revision plan based on trial results is available.	5
Mean		**95**

Table 3. presents the results of the instructional design expert validation of the instructional strategy used in the Learning Management System (LMS) based learning process. Based on the data presented in Table 3., the percentage score of the instructional design validity level was calculated according to the criteria proposed by Arikunto (2010), as described below:

$$Percentage = \frac{Answer}{N\ X\ Highest\ Weight} X\ 100\%$$

$$Percentage = \frac{95}{19\ X\ 5} X\ 100\% = 100\%$$

After being converted using the predetermined feasibility criteria, the obtained percentage score of 100% falls into the “very good” qualification category, exceeding the established threshold in the feasibility analysis (analisis ambang kelayakan). Based on the qualitative synthesis of expert feedback (sintesis umpan balik ahli kualitatif), instructional design experts consistently emphasized that the strategies implemented within the Learning Management System (LMS) including structured content delivery, interactive activities, and intuitive navigation were aligned with principles of heuristic evaluation in digital learning environments, which focus on usability, accessibility, and user experience optimization.

Recent studies support that heuristic evaluation is an effective method for identifying usability and interaction issues in digital learning systems and ensuring alignment between interface design and pedagogical goals (Kurnia et al., 2025; Miranda & Ghina, 2025). Furthermore, research on e-learning environments highlights that well-designed digital learning systems that integrate usability, motivation, and learning support significantly enhance students’ engagement and learning effectiveness (Fayda-Kinik, 2026).

The convergence of these findings indicates that the LMS-based instructional strategies applied in this study have successfully achieved a pedagogical feasibility balance, where aspects of validity, usability, and instructional effectiveness are simultaneously fulfilled. Therefore, the product was deemed highly feasible for implementation and recommended for trial use without revision, as it meets both quantitative feasibility standards and qualitative expert validation grounded in contemporary heuristic evaluation frameworks.

2. Small Group Test Results

The small-group trial represents the initial stage of implementing the developed product and serves as a formative evaluation of the LMS-based distance learning strategy. This stage aims to examine in depth the feasibility of the instructional strategy, the clarity of the learning flow, and the alignment of learning activities with the characteristics of students

as adult learners who are required to demonstrate self-directed learning. The small-group trial involved 23 students selected from a single class offering to represent variations in academic ability and experience in using a Learning Management System. Through this trial, the researcher was able to directly identify the extent to which students could understand instructional guidelines, access and utilize LMS features, and carry out self-directed learning activities designed to foster self-directed learning, such as learning planning, time management, and independent exploration of learning resources.

During the implementation of the small-group trial, students participated in the entire sequence of distance learning activities, which included the presentation of learning objectives, gradual delivery of instructional materials, online discussion activities, and LMS-based assignments. The researcher observed students' responses, levels of engagement in learning activities, and obstacles encountered during the learning process. Data collected through student response questionnaires, instructional implementation observation sheets, and open-ended feedback were used to evaluate the clarity of the materials, the appropriateness of the difficulty level, and the effectiveness of learning activities in supporting students' conceptual understanding. The results of the small-group trial served as the basis for revising and refining the LMS-based distance learning strategy, particularly in terms of learning activity design, content presentation, and the strengthening of support for students' self-directed learning processes. The recapitulation of the small-group trial assessment scores is presented as follows:

Table 4. Small Group Trial Questionnaire Results

No	Aspects assessed	Average Score	Category
1	I manage my study time independently.	86%	Practical
2	I create a study plan before participating in LMS-based learning activities.	81%	Practical
3	I am able to focus on learning without direct supervision from the lecturer.	82%	Practical
4	I motivate myself to complete assignments on time.	91%	Very Practical
5	I seek additional learning materials to deepen my understanding.	83%	Practical
6	I evaluate my understanding after completing the learning materials.	83%	Practical
7	I arrange my own study schedule during online learning.	83%	Practical
8	I am able to set weekly learning targets independently.	82%	Practical
9	I use discussion forums to clarify my understanding.	81%	Practical
10	I develop learning strategies that suit my learning style.	81%	Practical
11	I feel responsible for my own learning	88%	Practical

	outcomes.		
12	I often assess whether my learning methods are effective.	86%	Practical
13	I feel comfortable engaging in independent learning through the LMS.	85%	Practical
14	I seek information when I do not understand the material.	84%	Practical
15	I independently take notes on key points during online learning.	84%	Practical
16	I revise my learning strategies when I do not yet understand the material.	80%	Practical
17	I take the initiative to study the material before sessions begin.	81%	Practical
18	I feel that I have control over my own learning process.	81%	Practical
19	I reflect on my learning outcomes after exams or assignments.	82%	Practical
20	I continue learning even when there are no assignments or exams.	81%	Practical
Mean		**1665**	

Based on the research results obtained through questionnaires, the percentage results of the small-group trial regarding the development of an LMS-based distance learning strategy to improve students' self-directed learning and conceptual understanding are presented as follows:

$$Percentage = \frac{\Sigma(Percentage\ of\ Items\ per\ Questionnaire)}{Number\ of\ Questions} X\ 100\%$$

$$Percentage = \frac{1665}{20} X\ 100\% = 83\%$$

Based on the average results of the development of the LMS-based distance learning strategy to improve students' self-directed learning and conceptual understanding, involving 23 students, a percentage score of 83% was obtained, which falls into the practical qualification. This indicates that the developed LMS-based distance learning strategy is considered practical and does not require revision.

3. Large Group Test Results

The large group trial represents a subsequent stage conducted after the LMS based distance learning strategy was revised based on the results of the small-group trial. This stage aimed to examine the practicality and effectiveness of the instructional strategy under actual learning conditions by involving 50 students. In the large-group trial, the LMS-based distance learning strategy was implemented comprehensively in accordance with the established instructional design, encompassing both synchronous and asynchronous learning activities. Students were guided to actively manage their learning processes, beginning with setting learning goals, utilizing learning materials and resources available

in the Learning Management System, and engaging in reflection on their learning outcomes.

The assessment of the large-group trial was not only focused on the implementation of the learning process, but also on students' learning outcomes. The measurement of self-directed learning was conducted to determine the extent to which students demonstrated increased learning independence, including their ability to regulate learning strategies, initiative in completing assignments, and responsibility for the learning process. In addition, the measurement of conceptual understanding was carried out through tests or learning evaluations designed to assess students' abilities to understand, connect, and apply the concepts learned. The data obtained from the large-group trial were analyzed to evaluate the effectiveness of the LMS-based distance learning strategy in significantly improving students' self-directed learning and conceptual understanding. The recapitulation of the large-group trial assessment scores is presented as follows:

Table 5. Results of the Large Group Trial Questionnaire

No	Aspects assessed	Average Score	Category
1	I manage my study time independently.	96%	Very Practical
2	I create a study plan before participating in LMS-based learning activities.	92%	Very Practical
3	I am able to focus on learning without direct supervision from the lecturer.	97%	Very Practical
4	I motivate myself to complete assignments on time.	97%	Very Practical
5	I seek additional learning materials to deepen my understanding.	98%	Very Practical
6	I evaluate my understanding after completing the learning materials.	96%	Very Practical
7	I arrange my own study schedule during online learning.	98%	Very Practical
8	I am able to set weekly learning targets independently.	96%	Very Practical
9	I use discussion forums to clarify my understanding.	98%	Very Practical
10	I develop learning strategies that suit my learning style.	98%	Very Practical
11	I feel responsible for my own learning outcomes.	99%	Very Practical
12	I often assess whether my learning methods are effective.	98%	Very Practical
13	I feel comfortable engaging in independent learning through the LMS.	98%	Very Practical

14	I seek information when I do not understand the material.	98%	Very Practical
15	I independently take notes on key points during online learning.	98%	Very Practical
16	I revise my learning strategies when I do not yet understand the material.	99%	Very Practical
17	I take the initiative to study the material before sessions begin.	98%	Very Practical
18	I feel that I have control over my own learning process.	99%	Very Practical
19	I reflect on my learning outcomes after exams or assignments.	98%	Very Practical
20	I continue learning even when there are no assignments or exams.	97%	Very Practical
Mean		**1948**	

Based on the research results obtained through questionnaires, the percentage results of the large-group trial regarding the development of an LMS-based distance learning strategy to improve students' self-directed learning and conceptual understanding are presented as follows:

$$Percentage = \frac{\Sigma(Percentage\ of\ Items\ per\ Questionnaire)}{Number\ of\ Questions} X\ 100\%$$

$$Percentage = \frac{1948}{20} X\ 100\% = 97\%$$

Based on the average results of the development of the LMS-based distance learning strategy to improve students' self-directed learning and conceptual understanding, involving 50 students, a percentage score of 97% was obtained, which falls into the very practical qualification. This indicates that the developed LMS-based distance learning strategy is highly practical and does not require revision.

4. Product Effectiveness Results on Concept Understanding

The N-Gain test was used in this study to determine the level of improvement in students' conceptual understanding after participating in learning activities using the developed LMS-based distance learning strategy. This test aimed to measure the extent of change in students' abilities from the initial condition before instruction (pre-test) to the final condition after instruction (post-test), while taking into account the maximum possible score. Thus, the N-Gain test provides a more proportional depiction of the effectiveness of the instructional strategy compared to merely examining score differences.

In this study, the N-Gain test was applied to data obtained from students' conceptual understanding tests administered before and after the implementation of the LMS-based distance learning strategy. The pre-test was conducted to identify students' initial levels of conceptual understanding, while the post-test was administered after students completed the entire sequence of distance learning activities designed to foster self-directed learning and strengthen conceptual understanding. The conceptual understanding test was developed based on indicators aligned with the learning objectives; therefore, the improvement in scores reflects a genuine change in students' conceptual understanding.

The calculation of the N-Gain value was conducted by comparing each student's pre-test and post-test scores with the maximum possible score, resulting in a normalized gain value. The N-Gain values were then classified into high, moderate, and low improvement categories. These categories were used as the basis for interpreting the level of effectiveness of the LMS based distance learning strategy in improving students' conceptual understanding. The higher the N-Gain value obtained, the greater the improvement in students' conceptual understanding after participating in learning activities using the developed strategy. The SPSS analysis results are presented as follows:

Table 6. N-Gain Test Results Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	50	-2,00	1,00	,4514	,64206
Ngain_Persen	50	-200,00	100,00	45,1379	64,20623
Valid N (listwise)	50				

The results of the descriptive statistical analysis indicate that a total of 50 students participated in the N-Gain test. The N-Gain scores ranged from a minimum value of –2.00 to a maximum value of 1.00, with a mean score of 0.4514 and a standard deviation of 0.64206. The average N-Gain score of 0.4514 indicates that, overall, students experienced an improvement in conceptual understanding at the moderate category after participating in learning activities using the LMS-based distance learning strategy. This finding suggests that the developed instructional strategy was reasonably effective in enhancing students' conceptual understanding, although the overall improvement had not yet reached the high category.

The presence of a minimum N-Gain value of –2.00 indicates that a small number of students experienced a decline in learning outcome scores from the pre-test to the post-test. This condition may be attributed to several factors, such as limited student engagement in online learning activities, technical constraints in using the Learning Management System (LMS), or low student readiness to engage in learning approaches that require a high level of self-directed learning. Meanwhile, the maximum N-Gain value of 1.00 indicates that some students achieved an optimal improvement in conceptual understanding after participating in the learning process. This finding suggests that the LMS-based distance learning strategy is highly effective for students who are able to actively and independently utilize the learning environment.

In addition to the N-Gain scores, the table also presents N-Gain values in percentage form (Ngain_Persen), with a mean value of 45.1379% and a standard deviation of 64.20623. The average N-Gain percentage further supports the previous findings that the improvement in students' conceptual understanding falls within the moderate category, indicating that the learning process had a positive impact on students' learning outcomes. However, the relatively high standard deviation suggests considerable variability in the level of improvement among students, indicating that the effectiveness of the instructional strategy was not evenly distributed across all participants.

Overall, the results of the N-Gain analysis indicate that the developed LMS-based distance learning strategy is effective in improving students' conceptual understanding at a moderate level. The relatively large variation in N-Gain values suggests that learning success is strongly influenced by students' levels of self-directed learning. Students with high self-directed learning skills tended to achieve greater improvements in conceptual understanding, whereas those with lower levels of learning independence showed more limited improvement. Therefore, the N-Gain results reinforce the conclusion that the

developed instructional strategy is feasible and effective; however, it still requires further strengthening in terms of guidance and facilitation of self-directed learning to ensure more equitable improvements in students' conceptual understanding.

The development of the LMS-based distance learning strategy in this study was grounded in a systems approach to instruction, in which all instructional components were designed in an integrated manner to achieve the objectives of enhancing students' self-directed learning and conceptual understanding. Learning is viewed as a system consisting of objectives, content, instructional strategies, media, and evaluation that interact with one another and cannot function independently (Setyosari, 2001).

This systems approach is particularly important in the context of distance learning due to the shift in the instructor's role from an information transmitter to a facilitator of students' self-directed learning. In this context, the Learning Management System (LMS) serves not only as a medium for content distribution but also as a learning environment that structures learning sequences, interactions, and evaluations in an organized manner. This perspective strengthens the argument that the success of distance learning is determined not merely by the technology used, but more importantly by a systematic and well-designed instructional framework.

The Dick and Carey development model was selected because it emphasizes alignment among learning objectives, analysis of learner characteristics, instructional strategies, and learning outcome evaluation. This model is highly relevant for the development of distance learning because it provides a systematic workflow that supports sustained self-directed learning and conceptual understanding.

The implementation of the ten stages of the Dick and Carey model enables the development of a distance learning strategy that is oriented not only toward the final product, but also toward the learning process itself. Each stage, from goal identification to summative evaluation, is interconnected and functions as a quality control mechanism within the instructional system. This is particularly important in the context of Learning Management Systems (LMS), where learning processes occur asynchronously and require a high level of student autonomy.

The research findings indicate that the LMS-based digital learning module significantly contributes to the enhancement of students' self-directed learning. The module was designed with independent, adaptive, and interactive characteristics, enabling students to regulate their learning goals, select appropriate learning resources, and independently evaluate their learning progress.

The improvement in self-directed learning is reflected in the questionnaire results, which show an increase in scores from the practical category in the small-group trial to the very practical category in the large-group trial. These findings suggest that the design of the digital learning module, which incorporates reflective activities, independent practice, and automated feedback, effectively strengthens students' initiative and self-regulation in the learning process.

In addition to enhancing self-directed learning, the LMS-based distance learning strategy was also proven to be effective in improving students' conceptual understanding. This is evidenced by the results of the N-Gain analysis, which revealed a significant improvement between pre-test and post-test scores after students engaged with the digital learning module.

The improvement in conceptual understanding indicates that systematically designed distance learning can effectively support higher-order cognitive processes at the level of understanding (C2), such as interpreting, classifying, summarizing, and explaining relationships among concepts. The developed digital learning module provides conceptual representations in various formats, including text, multimedia, and interactive exercises, thereby facilitating deeper conceptual understanding.

These findings are consistent with the revised Bloom's taxonomy proposed by Anderson and Krathwohl (2001), which emphasizes that conceptual understanding does not solely depend on information delivery, but rather on learners' active engagement in processing and

reflecting on the learning materials. In this study, the LMS functioned as a medium that facilitated this process through self-directed learning activities and continuous formative assessment.

Overall, the findings of this study indicate that the LMS-based distance learning strategy developed using the Dick and Carey model is effective in improving students' self-directed learning and conceptual understanding. The integration of instructional design, digital learning modules, and the LMS not only enhances learning flexibility, but also functions as a pedagogical intervention that promotes sustained learner autonomy and conceptual mastery.

These results reinforce the view that effective distance learning must be designed as an integrated instructional system rather than merely as the use of technology. Therefore, the LMS-based distance learning strategy can be considered a valid and effective alternative for higher education learning, particularly in supporting the development of self-directed learners and deep conceptual understanding.

CONCLUSION

This study resulted in the development of an LMS-based distance learning strategy that was systematically designed using the Dick and Carey instructional design model. The developed instructional strategy is integrated with digital learning modules, instructional syntax, and evaluation instruments specifically designed to support students' self-directed learning and conceptual understanding in the context of distance learning.

The findings indicate that the developed LMS-based distance learning strategy is valid, practical, and effective for implementation in higher education learning. Product validity was demonstrated through expert evaluations conducted by subject matter experts, media experts, and instructional design experts, all of which yielded very good qualification categories. The practicality of the instructional strategy was evidenced by increased positive student responses in both small-group and large-group trials.

In terms of effectiveness, the implementation of the LMS-based distance learning strategy was proven to enhance students' self-directed learning, as reflected in their ability to set learning goals, manage time effectively, and independently evaluate their learning processes. Furthermore, the instructional strategy significantly improved students' conceptual understanding, as indicated by the results of the N-Gain analysis comparing pre-test and post-test scores.

These findings emphasize that systematically designed instructional strategies that are integrated with an LMS and oriented toward self-directed learning play a crucial role in improving the quality of distance learning. Therefore, the developed LMS-based distance learning strategy can be considered an effective alternative instructional model for higher education, particularly in fostering sustained learner autonomy and deep conceptual understanding.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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