



E-Learning Application based on Gagne's Instructional Design Model (E-DBLEARN)

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ABSTRACT

Learners often struggle with the complex and interconnected terminology in database environments and data modeling, leading to difficulties in understanding and applying key concepts effectively. In addition, a preliminary study has revealed that inadequate classroom facilities, varying learning styles, and the use of external resources that are not tailored to the syllabus have negatively impacted the understanding of theory-based topics. This study aims to achieve several objectives: identifying requirements of an e-learning application for Introduction to Database, design and develop the e-learning application and evaluating the e-learning application's functionality and usability. This research has been initiated by preliminary analysis on the application requirements based on literature review and surveys. The design phase followed, producing essential diagrams which are navigation maps and storyboards. The development was utilizing Adobe Animate, Adobe Premiere Pro, Adobe Audition and Adobe Photoshop for producing the application for learning database. Lastly, the functionality and usability of the application was verified through testing. Usability testing involved expert evaluation with input from three experts. The results acquired give a positive indicator for further implementation. Further evaluation with 30 respondents from the target users has produced results indicated high satisfaction with the application's overall usability, particularly in visual design and self-assessment and learnability constructs, which achieved the highest mean scores of 4.80 with standard deviations of 0.41 and 0.48, respectively. In conclusion, E-DBLEARN offers university students studying database courses an interactive, multimedia-rich platform expected to boost engagement, understanding, and self-directed learning, while equipping lecturers with an effective tool to teach theoretical concepts in the database courses. Gagne's Instructional Design Model was incorporated to ensure that learning is effective, efficient, and structured by guiding the instructional process through a systematic approach.

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1. Introduction

E-learning, often referred to as online or web-based learning, leverages telecommunication technologies to deliver educational content and training to students through applications or web browsers. This method of learning is reshaping education by offering flexible, accessible, and personalized experiences, making it easier for learners to access information and engage with course material anytime, anywhere [1],[2]. Nowadays, e-learning is increasingly becoming the standard for modern education. Unlike traditional teaching approaches, e-learning allows learners to participate in a structured learning environment from anywhere in the world, enabling the transfer of skills and knowledge to many recipients simultaneously or at different times, leading to greater multidirectional communication [3]. In addition to its accessibility and flexibility, e-learning's effectiveness is further amplified by the integration of multimedia, which enriches the learning environment and supports diverse learning styles.

Multimedia plays a crucial role in e-learning by enhancing the learning experience through the integration of various forms of media such as text, audio, video, graphics, and interactive elements, which together create a more engaging, interactive, and effective educational environment. This combination not only caters to different learning styles but also aids in better retention and understanding of complex concepts, making e-learning a dynamic and versatile approach to education [2],[3]. Multimedia improves e-learning by supporting various learning styles, and its value is especially clear in subjects like database environments, where complex terms can be hard for students to grasp.

Learners often struggle with the complex and interconnected terminology in database environments and data modeling, leading to difficulties in understanding and applying key concepts effectively. A preliminary study was conducted in Universiti Teknologi Mara (Terengganu Branch) focusing on database courses. Numerous database courses, both introductory and advanced, are offered to students across various programs. In the course, students encounter a diverse range of topics that are theoretical, conceptual, and practical, encompassing areas such as data modeling, normalization theories, and hands-on SQL programming [4],[5]. The study has revealed that inadequate classroom facilities, varying learning styles, and the use of external resources that are not tailored to the syllabus have negatively impacted the understanding of theory-based topics.

To address these challenges, it is essential to develop and implement targeted strategies that enhance both the teaching and learning of complex database concepts, ensuring that students are better equipped to grasp and apply the material effectively. Therefore, incorporating interactive multimedia content as additional learning material can be an effective tool to assist students in mastering these topics [2],[3]. The objectives of the study are to identify the requirements of an e-learning application for Introduction to Database course, design and develop the e-learning application and evaluate the e-learning application's functionality and usability. Interactive tools can make learning more engaging and help students see how terms are applied in real scenarios, thereby making the terminology less intimidating and improving overall comprehension [2],[6].

2. Literature Review

2.1 E-Learning Application using Multimedia Technology

E-learning applications have transformed education by providing flexible, accessible learning experiences through digital platforms. These applications offer a range of features such as interactive content, multimedia resources, and assessment tools that cater to diverse learning styles and needs [7]. They support asynchronous learning, allowing students to access materials at their convenience and from various locations, which promotes inclusivity and accommodates different schedules [8]. E-learning also facilitates personalized learning paths through adaptive technologies and data analytics, enhancing the effectiveness of education by tailoring instruction to individual progress and preferences [9]. However, challenges such as the digital divide and varying levels of learner engagement must be addressed to maximize their potential [10].

The integration of multimedia technology within e-learning applications significantly enhances their effectiveness. Multimedia elements, such as videos, animations, and interactive graphics, make learning more engaging by providing visual and auditory stimuli that complement textual information [11]. This multimodal approach caters to different sensory preferences, making complex concepts easier to understand and remember [2]. Moreover, multimedia technology enables the creation of rich, interactive learning environments where students can explore simulations,

participate in virtual labs, and experience scenarios that would be difficult to replicate in traditional classrooms [12]. The synergy between e-learning applications and multimedia technology, therefore, not only enriches the learning experience but also helps bridge the gap between theory and practice [13].

2.2 Database Course

Database courses are offered in various programs at multiple levels in the University. A database course is crucial because it equips students with essential skills for managing and structuring data, which is foundational to virtually all areas of computer science. As data-driven decision-making becomes increasingly prevalent across industries, understanding how to efficiently store, retrieve, and manipulate data is vital. The course provides knowledge in key areas such as data modeling, SQL, and database management systems (DBMS), which are critical for designing and maintaining robust and scalable data systems. These skills are not only fundamental for software development but also for emerging fields like data science, artificial intelligence, and cloud computing. Given the centrality of data in today's digital economy, a database course is indispensable for preparing students to tackle complex data challenges and contribute meaningfully to the development of advanced technological solutions.

2.2.1 Database Environment and Data Model

The database environment topic covers the infrastructure, tools, and methodologies used to store, manage, and retrieve data. It includes the database management system (DBMS), which serves as the core software for handling data operations, as well as the hardware, software, users, and procedures that ensure data integrity, security, and availability. The environment supports various tasks such as data definition, manipulation, and control, which are crucial for managing large datasets efficiently in modern applications [14].

Data models, on the other hand, describe the logical structure of a database, defining how data is organized, stored, and interrelated. They serve as blueprints for creating databases and play a vital role in ensuring data consistency and integrity. There are various types of data models, including relational, hierarchical, network, and object-oriented models, each tailored to specific needs and use cases [15]. The relational data model, proposed by E.F. Codd, remains the most prevalent, representing data in tables (relations) that can be queried using SQL. Modern advancements have led to the development of more complex models, such as NoSQL and graph databases, to address the needs of big data and real-time applications [16].

2.3 Gagne Instructional Design Model

The Gagne Instructional Design Model is a systematic approach to instructional design that aims to improve learning outcomes through a structured sequence of events. The model is based on nine instructional events that are designed to guide learners through the process of acquiring new knowledge and skills effectively. The Gagne model contributes to enhancing learning by ensuring that instructional activities are designed to address each critical step in the learning process. It provides a clear framework that helps educators create effective learning experiences that engage learners, support their understanding, and reinforce their skills. The model's structured approach also facilitates the design of assessments and feedback mechanisms that are integral to successful learning outcomes [17]. Table 1 summarizes nine instructional events from Gagne's model.

Table 1. Nine Events in Gagne's Instructional Design Model [17]

Gaining Attention	Informing Learners of Objectives	Stimulating Recall of Prior Learning
Capturing learners' interest to prepare them for learning.	Clearly stating what learners will be able to do after the instruction.	Activating previous knowledge related to the new content.
Presenting the Content	Providing Learning Guidance	Eliciting Performance
Delivering new information in a structured and organized manner.	Offering hints, examples, and support to help learners understand the content.	Allowing learners to practice and apply what they have learned.
Providing Feedback	Assessing Performance	Enhancing Retention and Transfer
Offering corrective feedback to reinforce correct performance and address errors.	Evaluating learners' ability to perform the learned skills or knowledge.	Using strategies to help learners retain and apply knowledge in different contexts.

3. Methodology

The development of the E-DBLEARN application was guided by the ADDIE model, a widely recognized instructional design framework that encompasses five phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase played a crucial role in ensuring the systematic creation of an effective e-learning tool tailored to the needs of students and educators in introductory database courses. Table 2 provides a comprehensive overview of the methodology employed for the E-DBLEARN project, detailing the critical steps taken at each phase to ensure the successful development and deployment of the application.

Table 2. E-DBLEARN Project Methodology

Phases	Activities	Outcomes
Analysis	<ul style="list-style-type: none"> Distribute questionnaires to target users Identify problem Consult with Subject Matter Expert (SME) Conduct literature review 	<ul style="list-style-type: none"> User problems Requirements and content of the e-learning application
Design	<ul style="list-style-type: none"> Design navigation map Design storyboard for e-learning content Design test plan Design usability question form for expert 	<ul style="list-style-type: none"> Navigation map Storyboard Test plan Expert evaluation form
Development	<ul style="list-style-type: none"> Develop e-learning application based on designed storyboard 	<ul style="list-style-type: none"> Completed e-learning application for Introduction to Database (E-DBLEARN)
Implementation	<ul style="list-style-type: none"> Test the developed e-learning application functionality 	<ul style="list-style-type: none"> Published e-learning application. The results of E-DBLEARN's functionality
Evaluation	<ul style="list-style-type: none"> Evaluate the developed e-learning application usability Conduct expert evaluation 	<ul style="list-style-type: none"> The results of E-DBLEARN's usability

The first phase, Analysis, focuses on identifying and understanding the needs of the target users, which includes university students and lecturers engaged in database courses. During this phase, questionnaires were distributed, and research was conducted to identify problems in current course delivery for the introduction topics consisting of complex terminologies. Subject Matter Experts (SMEs) were consulted to ensure alignment with educational standards, and an online Google Form questionnaire was used to gather target users' feedback. This phase resulted in identifying key user problems and finalizing the content and functional requirements for the E-DBLEARN application.

In the Design phase, insights from the analysis were translated into a detailed plan for the application's structure and content. A navigation map was created to outline the user interface's layout, ensuring an intuitive experience that facilitates learning. Additionally, a storyboard was developed to visually represent the instructional design, integrating multimedia elements and interactive features for enhanced engagement. The deliverables, including a comprehensive navigation map and storyboard, served as blueprints guiding the application's development. Figure 1 shows the storyboard sample for E-DBLEARN.


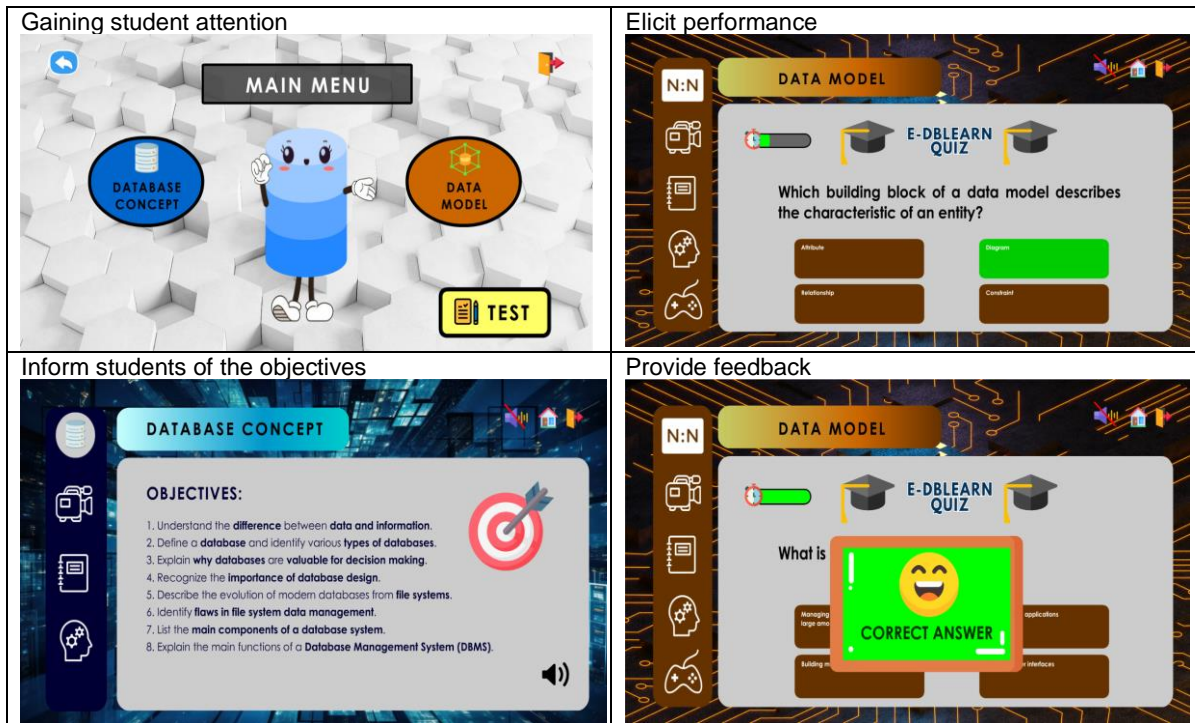
PAGE :	3	PAGE TITLE:	DATABASE CONCEPT
USER SEES:			
Page title of DATABASE CONCEPT, Objectives of the topics display on the box with speaker icon, navigation bar menu with three icons (camera, notebook, brain generator), home icon and X button.			
USER HEARS:		GRAPHIC ASSETS	
Voice Over (VO): <i>"Welcome to database concept topics! Enjoy learning the database concept topics with watching video animation of database concept, interactive notes with interesting media applied and you can engage your understanding of this topics by participate in quiz section that have three level of difficulties provided to you!"</i>		G1: 3D graphic background (iStock) G2: Camera icon G3: Notebook icon G4: Brain generator icon G5: Speaker icon G6: Database model icon G7: Home icon	
ON-SCREEN TEXT		ADDITIONAL NOTES	
T1: Enjoy learning the database concept topics with watching video animation of database concept, interactive notes with interesting media applied and you can engage your understanding of this topics by participate in quiz section that have three level of difficulties (Easy, Medium, and Hard).		A1: Icon of database model, camera, notebook and brain generator will be place in navigation menu bar at the left side of the page A2: The content display on the box beside the navigation bar A3: The main navigation home icon and X button are placed at the top right page.	
INTERACTIVITY			
Speaker icon: Turn on the voice over Camera icon: Display animation video Notebook icon: Display interactive notes page Brain Generator icon: Display quiz page Database model icon: Display database concept main page			

Figure 1. Storyboard Sample

The Development phase focuses on constructing the E-DBLEARN application by bringing the design concepts to life, emphasizing the integration of interactive multimedia elements to enhance the learning experience and adapting with Gagne's Nine Event of Instruction Model. Adobe tools were used to develop graphical, animated, video, and audio components, with continuous testing and refinement ensuring a fully functional and engaging e-learning application ready for deployment. Figure 2 illustrates snapshots of the application interface that are developed based on the model selected.



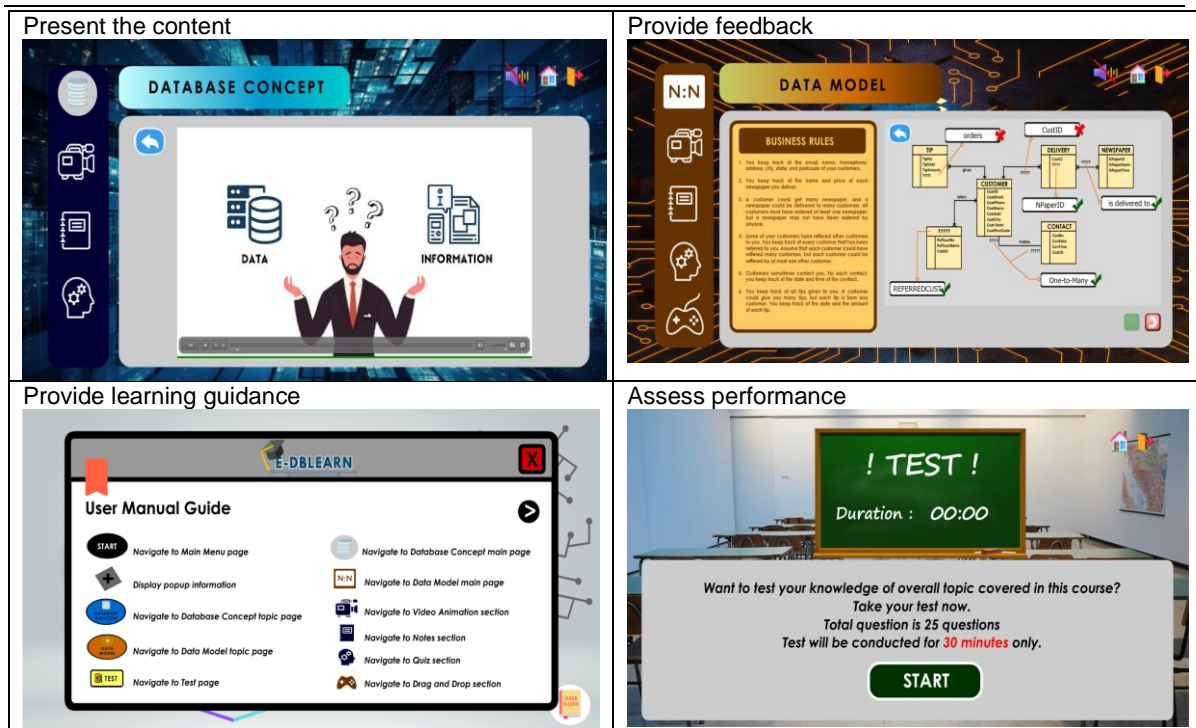


Figure 2. Interface snapshots of E-DBLEARN based on Gagne's Model

In the Implementation phase, the E-DBLEARN application underwent testing according to a comprehensive test plan to ensure its functionality and resolution of technical issues. After successful testing, the application was published as a .exe file and deployed to the target audience, marking its transition from development to ready to use application for further evaluation.

The Evaluation phase assessed the E-DBLEARN application's effectiveness and usability through expert evaluations, with findings informing future updates to maintain its educational value, and the results are presented in Section 4.

4. Results and Discussion

Functionality testing was conducted by both developers and testers. This test included various components of the application: the Start Page, Main Menu Page, Database Concept and Data Model Topics Main Menu Page, Video Section, Notes Section, Quiz Section, Games Section, Test Page, Exit Page, and all associated features. The results of this testing validated that all functionalities in E-DBLEARN were successful and operating as intended.

The expert evaluation of the E-Learning Application for Introduction to Database (E-DBLEARN) utilized a set of questionnaires based on eight criteria of usability evaluation as previously studied by [18]. These criteria were integrated with seven selected characteristics from Gagne's Nine Events of Instruction. The evaluation employed a Likert scale to measure usability, allowing for a nuanced assessment of each criterion, with options spanning from 5 (Strongly Agree) to 1 (Strongly Disagree), to gauge the experts' opinions and perceptions on the e-learning application's usability. The evaluators for the E-DBLEARN expert evaluation are three senior lecturers with over five years of experience in their respective Information Technology (IT) fields: database subjects, multimedia, and human-computer interaction.

According to the evaluation results, presented in Figure 3 to 10, all three experts rated every criterion with a score of 5 (Outstanding). This consistently high rating reflects that E-DBLEARN has been verified in the usability aspects of the application, affirming its effectiveness in delivering an optimal user experience. For the first usability criteria is content. The evaluation of the content aimed to assess the quality and relevance of the educational material in E-DBLEARN, ensuring it supports learning objectives and meets the target audience's needs. Experts' feedback verified that the content is well-organized, accurate, and effectively aligns with the educational goals.

SECTION A: CONTENT		
No.	Description	Expert Rate
1.	Appropriateness of language and terms used	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Quality and relevance of learning and supporting materials	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Accuracy and completeness of information provided	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
Expert 3: Everything okay		-

Figure 3. Result Expert Evaluation for Content

The second section is learning and support. This evaluation focuses on the effectiveness of the application's learning support features, including guidance, help resources, and feedback mechanisms. The experts found E-DBLEARN to excel in this area, highlighting its clear guidance and helpful resources that significantly enhance the user's learning experience.

SECTION B: LEARNING AND SUPPORT		
No.	Description	Expert Rate
1.	Effectiveness of delivering interactive contents (video animations, notes, quizzes, drag-and-drop games, test)	Expert 1: 4 Expert 2: 5 Expert 3: 5
2.	Quality of academic discussions and communication tools	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Adequacy of learning assessment methods	Expert 1: 5 Expert 2: 4 Expert 3: 5
Comment		Suggestion
Expert 2: Comply to all multimedia elements		Expert 3: Need to add instruction more as user guidance (quiz)

Figure 4. Result Expert Evaluation for Learning and Support

The third section is visual design. The purpose of assessing visual design was to evaluate the application's layout, design consistency, and overall aesthetic appeal to ensure a positive user experience. The experts gave high ratings for visual design, praising E-DBLEARN for its clear, consistent, and engaging visual elements.

SECTION C: VISUAL DESIGN		
No.	Description	Expert Rate
1.	Clarity and comprehensibility of the interface	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Effectiveness of layout, colour scheme, typography and multimedia elements (images, videos, audios and animations)	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Overall aesthetic appeal and user engagement	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
Expert 1: Add few more animation elements in courseware		Expert 2: Minor improvement to the layout design

Figure 5. Result Expert Evaluation for Visual Design

The fourth section is navigation, which aimed to determine how easily users can move through the application and access its features. Experts rated this section as excellent, noting that E-DBLEARN provides an intuitive and user-friendly navigation system, allowing for efficient access to various sections.

SECTION D: NAVIGATION		
No.	Description	Expert Rate
1.	Ease of browsing and locating information	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Intuitiveness of the navigation structure and flow	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Efficiency of accessing and utilizing features (quizzes, games, summative tests)	Expert 1: 5 Expert 2: 4 Expert 3: 5
Comment		Suggestion
-		Expert 2: Add label in execute answer for quiz

Figure 6. Result Expert Evaluation for Navigation

The fifth section is accessibility. It focuses on how well the application supports users with varying abilities, including those with disabilities. The experts rated E-DBLEARN highly for accessibility, indicating that it incorporates effective features for a broad range of users, including compatibility with assistive technologies.

SECTION E: ACCESSIBILITY		
No.	Description	Expert Rate
1.	Ease of accessing the application across various device	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Consistency of the user experience across different platforms	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Compliance with accessibility standards	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
-		-

Figure 7. Result Expert Evaluation for Accessibility

Next section is interactivity assessment sought to review the effectiveness of engaging features such as quizzes and simulations in the application. Experts found E-DBLEARN's interactive elements outstanding, noting that they effectively engage users and reinforce learning.

SECTION F: INTERACTIVITY		
No.	Description	Expert Rate
1.	Effectiveness of interactive tools within the e-learning application	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Quality and engagement level of interactive learning activities (quizzes, drag-and-drop games, summative tests)	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Responsiveness and reliability of interactive elements	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
-		-

Figure 8. Result Expert Evaluation for Interactivity

For self-assessment and learnability, this evaluation aimed to assess the application's support for self-assessment and ease of learning, including tools for tracking progress and mastering the system. Experts rated this section highly, noting that E-DBLEARN provides effective self-assessment tools and is easy for users to learn.

SECTION G: SELF-ASSESSMENT AND LEARNABILITY		
No.	Description	Expert Rate
1.	Quality of self-assessment tools	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Ease of learning how to use the e-learning application	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Support for autonomous learning and user guidance	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
-		-

Figure 9. Result Expert Evaluation for Self-Assessment and Learnability

Lastly, the motivation to learn evaluation focuses on how well the application engages users and fosters interest in learning. Experts gave excellent ratings, highlighting that E-DBLEARN effectively motivates users through its design and content, encouraging continued use and learning.

SECTION H: MOTIVATION TO LEARN		
No.	Description	Expert Rate
1.	Ability to engage and motivate learners through interactive content and multimedia elements	Expert 1: 5 Expert 2: 5 Expert 3: 5
2.	Support for setting and achieving learning goals	Expert 1: 5 Expert 2: 5 Expert 3: 5
3.	Overall enjoyment and satisfaction with the learning experience	Expert 1: 5 Expert 2: 5 Expert 3: 5
Comment		Suggestion
Expert 2: Well developed e-learning		

Figure 10. Result Expert Evaluation for Motivation to Learn

In conclusion, the functionality and usability testing of the E-DBLEARN demonstrated its effectiveness in delivering a high-quality learning experience. The comprehensive testing process, conducted by both developers and testers, ensured that all features operated as intended. Additionally, the expert evaluation, based on usability criteria and Gagne's instructional principles, confirmed that E-DBLEARN excels in critical areas such as content quality, learning support, visual design, navigation, accessibility, interactivity, self-assessment, and user motivation. With consistently high ratings from experienced lecturers, E-DBLEARN has been validated as an effective tool for facilitating database education, providing an engaging and accessible learning environment.

5. Conclusion

The E-DBLEARN e-learning application is developed as an assisting tool for teaching and learning of Database Environment and Data Model topic in any database courses. The problem that triggers development stems from the challenges faced by the learners in understanding the complex and interconnected terminology in database environments and data modeling, thus leading to difficulties in applying key concepts effectively. In addition, a preliminary study has revealed that inadequate classroom facilities, varying learning styles, and the use of external resources that are not tailored to the syllabus have negatively impacted the understanding of theory-based topics. The significance of the E-DBLEARN is that it provides interactive multimedia content based on the Gagne Instructional Design Model for the database course, which can be an effective additional learning material for students. This can contribute to the enhancement of both teaching and learning by helping students better understand and apply complex database concepts. Evaluation results from the expert feedback highlighted areas for potential improvements, including the addition of animations, enhanced user guidance and minor layout adjustments. The experts' suggestions offer valuable insights for further refinement, aiming to boost user engagement and interface intuitiveness. In summary, the expert evaluation confirms that E-DBLEARN meets its designated functions.

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Conflict of Interest

The authors declare there is no conflict of interest in the subject matter or materials discussed in this manuscript.

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	<p>Siti Nurul Hayatie Ishak is an academic staff in UiTM Terengganu, Kuala Terengganu branch.</p>	<p>References and formatting.</p>
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