

Application of Context-Aware and Collaborative Mobile Learning System Design Model in Interactive E-Book Reader Using Design Thinking Methods

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Abstract-E-books as a learning medium have been widely used and utilized to support learning processes. The presence of e-books as digital books can be accepted by users because of the interactive content and display. However, the current format of e-book has not provided a mechanism/platform that accommodates contemporary learning styles on a two-way networked learning basis. E-books are more static in the sense that it has minimal interaction context. E-books have not been able to integrate learners with their learning environment in an interaction construct to support a learning activity. To address this problem, this study recommends a new approach called context-aware and collaborative mobile learning system design model. The method used in implementing the design model is design thinking. Usability testing using the guerrilla usability testing method is carried out to determine the quality of the e-books produced. The results obtained at the stages of empathize and define produced list and learning problems experienced by students when using e-books. The ideate and prototype stages produced e-book prototypes developed based on context-aware and collaborative mobile learning system design model. In the test stage, usability testing of 30 students showed good results. It is said to be good because there are no assignments with a score of one in the rubric usability testing table. So it can be concluded that the design model applied to the prototype e-book is feasible and can be understood by users.

Keywords: context-aware; e-book; design thinking

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1. Introduction

Mobile learning has become a very important learning style in modern life. In the concept of learning, mobile learning brings the benefits of the availability of teaching materials that can be accessed at any time by visualizing interesting material anytime and anywhere. Mobile learning is defined as a learning process through mobile devices that provides on-demand access to learning content and services (without the constraints of time, location, environment, and devices) [1]. In a mobile learning system, students can continue their education out of the classroom, move during the learning process and change places using mobile devices. This mobility causes changes in the learning context. In a learning process there are interactions between learners, by way of conveying thoughts to one another and taking appropriate action in an interactive session. When learners interact, they can understand and use information that is situational or information in the form of context that can improve the quality of interaction [2].

The term “context” first appeared in research conducted by Schilit and Theimer [3]. They define context as location, identities of people closest to, objects, and changes in the objects. Since then, many researchers have made efforts to propose an accurate definition of context on mobile computing devices. The most common definition is: “All information that can be used to describe the situation of an entity that participates in interactions between users and systems” [4]. In m-learning, context can be associated with information about the user (name, address, etc.), devices (Smartphone, PDA, Tablet, etc.), localization (at work, on the train, public places, etc.), time (time of the day, weekdays/holidays, etc.), activities (interaction activities, etc.), collaboration (tools, modes, collaboration activities, etc.) and, physical environment (brightness level, noise level, etc.) where all these elements can change the way users interact with whatever device is being used. In this context, information is useful for adjusting the interaction and application behavior with the student’s circumstances.

The use of e-books is an example of mobile learning. E-books are one of the learning media that are widely used and used to support learning processes. The presence of e-books as digital books can be accepted by users because of the interactive content and display that can be accessed anywhere and anytime [5]. However, the current format of e-book has not provided a mechanism/platform that accommodates contemporary learning styles on a two-way networked learning basis. E-books developed are more static in the sense that it has minimal interactive content [6]. It is static because e-books' current feature only allows learners to interact only with the e-books. Meanwhile, in the context of reading or learning, a learner may interact with other learners or even with his teacher / lecturer (in a discussion forum for example) related to the topic in the book he is reading.

The static features of this e-book have not been able to integrate learners with their learning environment in an interactive construct to support a learning activity. In an effort to improve the access context of learners with the learning environment, this study recommends a context aware and collaborative mobile learning system design model which is an ability that refers to a system in using contextual information to provide better services to users in a flexible and easy to manage fashion. To plan a design and model system in accordance with the needs of the user's situational context, a new model appears to answer these problems, namely the design thinking model. Design thinking is a new model in the design process and user-focused problem solving methods [7]. Design thinking itself was popularized by David Kelley and Tim Brown, founder of IDEO and design consultants with an innovative product-based design background.

Based on the above background this research focuses on the question: How to implement a context-aware and collaborative mobile learning system design on an interactive e-book reader using design thinking methods? It is hoped that through this research, we (1) find out the learning problems experienced by students when using e-books, (2) recommend a design model for a learning media in the form of context-aware and collaborative mobile learning system, and (3) determine the level of eligibility of the e-book after applying the context aware and collaborative mobile learning system design model.

2. Method

a. Research design

This study recommends a design model that is context aware design and collaborative mobile learning system applied to an interactive e-book reader. The design model was developed based on the design process and the user-focused problem solving method, namely design thinking. Figure 1 is the design of this study.

In this study we divided users into 2 groups. The first group acted as respondents who were asked to fill out a questionnaire about the needs and problems encountered when using e-books as a means of learning (Empathize

stage). Needs and problems obtained from questionnaires are grouped, sorted and compiled into a list of user needs (Define stage). Based on this list of user needs, a design model in the form of context-aware and collaborative mobile learning system was developed (Ideate stage). Then a prototype is made in the form of an e-book with the design of the model (Prototype stage). The second group acts as a tester or test model. The second group did not know about all the processes that were done before, so at this stage it was the first experience for the second group in prototype testing.

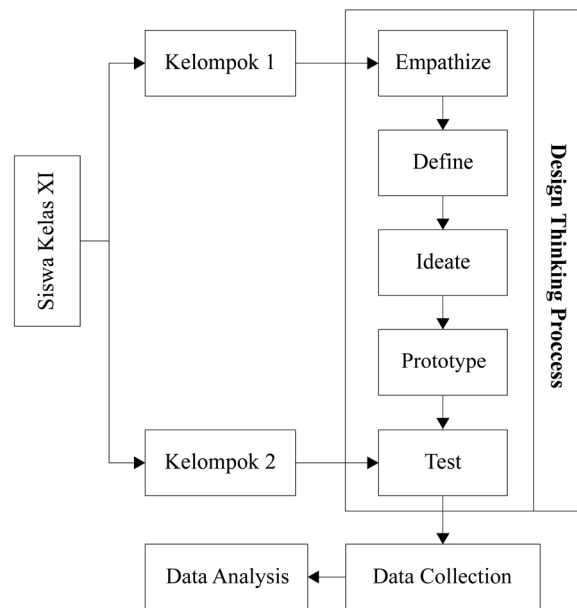


Figure 1. Research Design

Tests conducted are usability testing. Usability comes from the word usable which generally means it can be used well. Something can be said to be usable if the failure in its use can be eliminated or minimized and it provides benefits and satisfaction to users [8]. One method of usability testing is Guerrilla Usability Testing. The main point of this method is trying to capture first-time user experience [9]. This method is also the simplest method for testing a design by going to public places and asking people about the design. In addition, Guerrilla Usability Testing can be done when a design needs to be validated and tested quickly but with a low budget. Prototype testing at this test stage uses the Guerrilla Usability Testing method. At this stage the researchers collected data on the results of usability testing. These results are used to determine the feasibility of an interactive e-book reader prototype in which context-aware and collaborative mobile learning system designs are applied.

b. Research subject

This study included 60 students of class X majoring in TKJ (Computer Network Engineering) SMK Yapema, Gading Rejo, Pringsewu, Lampung. It consists of 2 classes where each class consists of 30 students. The first group consisted of 30 students as questionnaire filler

respondents. The questionnaire contains the needs and problems encountered when using e-books as a basis for developing applications. The second group consisted of 30 students acting as a tester to test the prototype that had been developed.

c. Application of design thinking

Design thinking is a very complex model because it is multi-disciplinary which involves various mindsets [10]. The stages in design thinking are as follows:

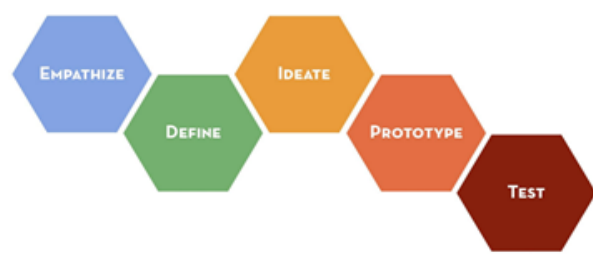


Figure 2. Design Thinking [10]

The first stage in design thinking is empathize, at this stage an observation is carried out in the form of giving questionnaires to research subjects, namely group 1 about the needs or problems encountered in using e-books as a learning tool. The second stage is define, at this stage the needs and problems obtained from the questionnaire are grouped, sorted and arranged into a list of user needs. The third stage is ideate, at this stage a list of user needs is processed. Based on this list of user needs, a design model in the form of context aware and collaborative mobile learning system was developed. The fourth stage is prototype, context aware design and collaborative mobile learning systems that have been developed based on user needs implemented into the prototype, which is an interactive e-book reader. The fifth stage is the test, at this stage the usability testing is done on the prototype with the Guerrilla Usability Testing method.

d. Research Instruments

The instruments used in this study were questionnaire and usability testing rubric. Questionnaire is used in the empathize stage. Then the usability testing rubric is used at the test stage to collect prototype feasibility test results.

e. Analysis and data collection

The data collection process starts at the time the design thinking process begins. The process of gathering problems and user needs is done at the empathize stage. In the define stage, grouping of problems or user needs is done, and then arranged into a list of solutions or ideas. At the ideate stage, the context aware and the collaborative mobile learning system design begin to be designed based on a list of solutions or ideas obtained from the define stage. After the model is arranged, it is implemented on an interactive e-book reader prototype. Then the feasibility test was conducted by group 2 using the guerrilla usability testing method to measure the usability level of the interactive prototype e-book reader.

3. Result

The research process begins when the design thinking process begins. There are 5 stages, as follows:

a. Empathize

The purpose of this stage is to collect user problems and needs. In group 1, 30 students were given a questionnaire containing questions about the needs and problems encountered when using e-books as a learning tool. The answers from filling out the questionnaire are collected, selected and sorted by the number that appears the most.



Figure 3. Filling out the questionnaire at the empathize stage

b. Define

The purpose of this stage is to analyze the results obtained from the empathize stage, namely finding urgent problems to be addressed. The steps at this stage are (a) grouping the various problems obtained from the empathize stage, (b) after the group is formed, rank from the largest to the smallest group, and (c) the group with the largest number is the most urgent problem that must be addressed. Based on the results of data retrieval from the questionnaire and through several stages above, researchers only took 4 needs or problems with the largest number. The 4 list of user requirements are as follows:

1. Book recommendation according to the user's circumstances
2. Chapter recommendation according to user's circumstances
3. Messaging feature as a means of discussion with fellow students.
4. Interactive quiz with recommendations for the right answer chapter

c. Ideate

The purpose of this stage is to gather ideas that can solve the problems obtained from the define stage. Problems and needs obtained are then developed into a design model. It is at this stage that a context aware and collaborative mobile learning system design model is developed. Based on previous research on context aware conducted by several researchers, context-aware applied is about a system designed to support students in learning specific courses, which has specific learning objectives and pre-planned learning process [11]. By synthesizing the

system architecture from the relevant works, context aware design architecture in this study consists of three layers: context sensing layer, contextual adaptation layer, and application layer.

The context sensing layer contains various logic sensors to sense the learning context state. The second layer manages aspects of the direct context sensed from the context sensing layer and concludes the indirect context aspects. It also provides a set of learning adaptation and learning strategies that are appropriate depending on the learning context. The third layer, the application layer, is tasked with interacting with the users, such as gathering information and their requirements, displaying adaptive learning objects and providing the right communication approach. At this ideate stage the researcher recommends a model that is context-aware and collaborative mobile learning system design based on the problems collected at the define stage, as follows:

1. Book recommendation feature according to the user's situation

The context awareness applied is book recommendations based on user profiles. When the user first accesses the book's menu recommendations, the system recommends books according to the user's profile even without the need to fill in a search keyword. This book's recommendations are based on the user's profile, namely the level of education, interests, and work that is filled in by the user at the time the user processes the registration. The context aware design applied is as follows:

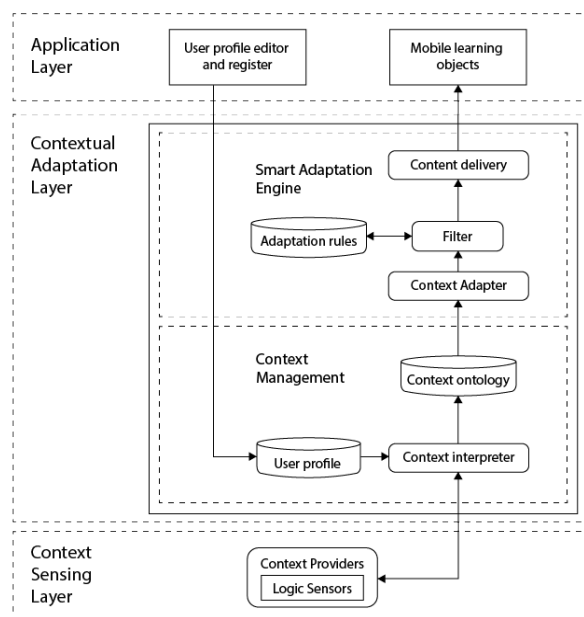


Figure 4. Architectural design context aware book recommendations

There are three layers in the context aware design, namely the application layer, the contextual adaptation layer and the context sensing layer. At the application layer the user registers by entering the level of education,

interests, and work, then stored in the user profile database. The data is then translated into a data context by a context interpreter. At the same time the system responds through the context provider in the form of a logic sensor at the context sensing layer. The translated data is entered into the ontology context database in the form of metadata. Data is forwarded by the context adapter to be filtered and adjusted to the appropriate adaptation rule. At the filter stage, the method used is the content base filtering method contained in the database adaptation rules. Content-based filtering is the provision of recommendations given by exploring the contents of user profiles, product descriptions or matters relating to the formation of user choices for an item [12].

Content-based filtering method forms the profile of its users based on the forming attributes of an item. The content-based filtering method algorithm is explained in the following stages: (a) A book item is broken down based on a component vector forming it, (b) the user will provide a value in the form of education, interest and work during the registration process which will be stored in the user's personal data profile, (c) then the system will form a user profile based on the weight of the component vector forming an item, namely by making a query of all the book's components and then calculating the weight using the TF-IDF algorithm. TF-IDF (Term Frequency-Inverse Document Frequency) algorithm is an algorithm that can be used to analyze the relationship between a phrase / sentence and a collection of documents [13]. In calculating the weight of TF-IDF the following formula is used:

$$W = TF * ((D/DF) + 1) \tag{1}$$

From the results of calculations with formula (1) above, it can be seen that the book recommendations are in accordance with the user's situation based on the highest value to the lowest. The results are sent to the user at the context of delivery stage so that they can be received in the form of mobile learning objects namely recommended books.

2. Chapter recommendation according to user circumstances

According to Nguyen (2010), the context in the m-learning model is information that has an influence on students in learning activities. Nguyen (2010) argues that there are several context factors that influence the adjustment of learning material for each student, namely: (a) Location, allowing information and services to be localized. Location allows the system of adaptation to places that are located where learners participate. (b) Time, refers to the time of day. Specifically, the interval at which students interact with the system is important for a number of subject matter that requires students to learn. (c) The level of concentration, as a context factor used for adaptation. This shows students' attitudes such as the level

of concentration when they are taking part in learning [14]. The context aware design applied is as follows:

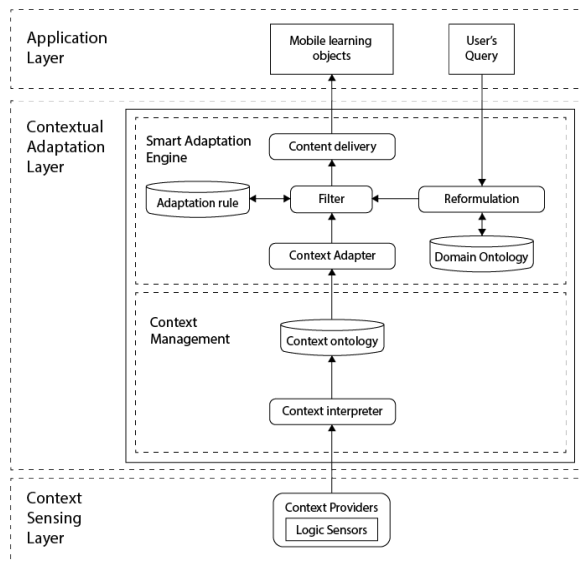


Figure 5. Architectural design context aware chapter recommendations

The context aware that is applied in this interactive e-book reader is the recommendation of book chapters that suits the user's situation. Each chapter is assigned difficulty level based on a scale of 1-3 namely easy = 1, medium = 2 and, difficult = 3 by the book uploader. When students open a book in their e-book, they are faced with a menu: their location, the amount of time they have, and the level of concentration. At the same time the system responds through context providers in the form of logic sensors at the context sensing layer. The translated data is entered into the ontology context database in the form of metadata. Data is forwarded by the context adapter to be filtered and adjusted to the appropriate adaptation rule. Then the system queries the user input at the application layer. Each input in the form of location, time and concentration level is converted into interval values 1-5, 1-5, and 1-3. The input query is then formulated and adjusted to the collaboration data contained in the ontology domain.

The ontology domain contains collaboration values from the three variables that are added together. Then the value collaborations are grouped in the following way: (a) Subtract the largest value with the smallest value to determine the range, (b) Determine the mean with a single non-frequency data,

$$X = \sum_{i=1}^n X_i \quad (2)$$

(c) Determine the standard deviation using the formula:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - x)^2}{n-1}} \quad (3)$$

(d) Classifying grades into easy, medium and difficult categories.

Table 1. Grouping criteria

Numb.	Level	Value	Criteria for grouping
1	Easy	1	Value < mean - SD
2	Medium	2	Mean - SD ≤ Value < mean + SD
3	Hard	3	Value ≥ mean + SD

After that, the grouping criteria scale values are obtained and then the matching results of the collaboration scores are performed with the difficulty level of each chapter. For example, the value of collaboration 7 is at the Medium level. Then the recommended chapter with a moderate level of difficulty that will appear to be recommended. The results are sent to the user at the context of delivery stage so that they can be received in the form of mobile learning objects, namely chapter recommendations that are appropriate to the user's situation.

3. Messaging feature as a means of discussion with fellow students

Collaborative mobile learning system is a learning strategy using mobile devices in which a collaborative learning learning strategy is embedded [15]. In this study using the message / message feature as a group learning media. Each student or user in studying a book in an e-book can create a study group with the theme of a particular chapter in a book. Friends studying in study groups are called learning partners. The minimum learning partner is 1 teacher / writer / uploader of the book. The context aware design applied is as follows:

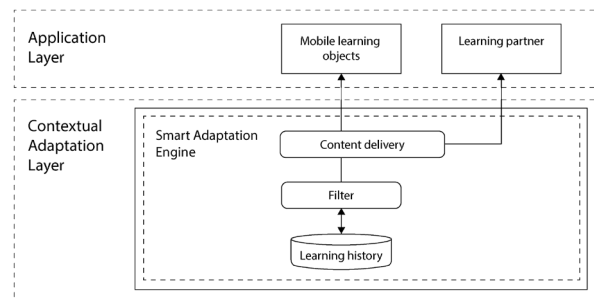


Figure 7. Architectural design context aware book recommendations

When a user accesses a mobile learning object in the form of a chapter, the user can create a discussion group with a learning partner. Every message with the chapter theme is sent by the user via content delivery to the filtered learning partner and then stored in the learning history database. So that the discussion in the form of a message is stored and can be accessed at any time.

4. Interactive quiz with recommendations for the right answer chapter.

The context aware applied is a chapter recommendation based on the results of a quiz in a book. Each book in this interactive e-book reader has

several quizzes. The quiz was created by the book's author / book uploader as a practice material for students / readers. Each question represents several chapters of the book. For example, quiz no. 3 is a question taken from chapter 4 material from the book. After students work on the quiz the system will count the number of true and false values in the learning evaluation. At the consolidator stage, the system collects grades with incorrect answers. Based on these values the system recommends appropriate learning materials or chapters so that it directs students to be able to answer the quiz correctly. The context aware design applied is in figure 8.

c. Prototype

This stage aims to design the application prototype in accordance with the design obtained at the ideate stage. The prototype developed is an interactive e-book reader running on the Android operating system. The first step is to create a user interface in the form of a low

fidelity design (Figure 9).

d. Test

The purpose of this stage is to determine the feasibility of the application prototype by knowing which steps are difficult for users to understand and skip. The test carried out is usability testing with the guerrilla usability testing method. Equipment needed in this stage is the usability testing rubric and prototype. The test takers were thirty students from the second group. The testing phase carried out is as follows: (a) give prototypes to students, (b) explain the scenario, (c) let students try prototypes based on scenarios, (d) record all student activities during the test, and (e) end the test we give students appreciation. We created 5 assignments that students must complete. The five tasks are as follows: (a) register as a user and open book recommendations, (b) open one of the books and fill in the state of self (location, time and concentration), (c) work on the quiz and receive chapter recommendations according to the correct answer, (d) exchange messages with learning partners, and (e) bookmark a book

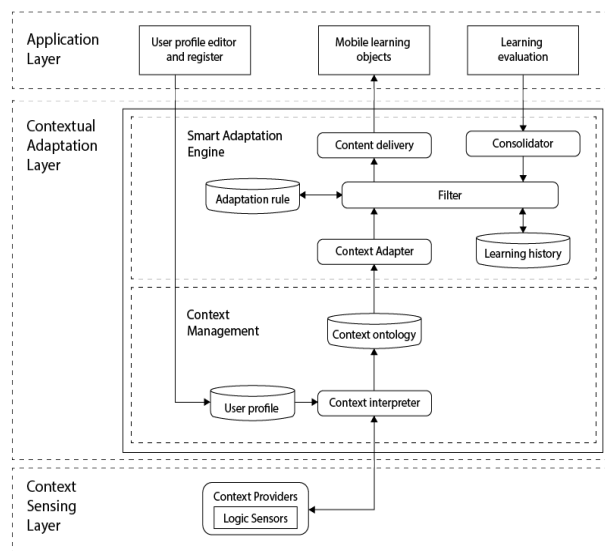


Figure 8. Architecture aware context design recommendations appropriate chapter answers.

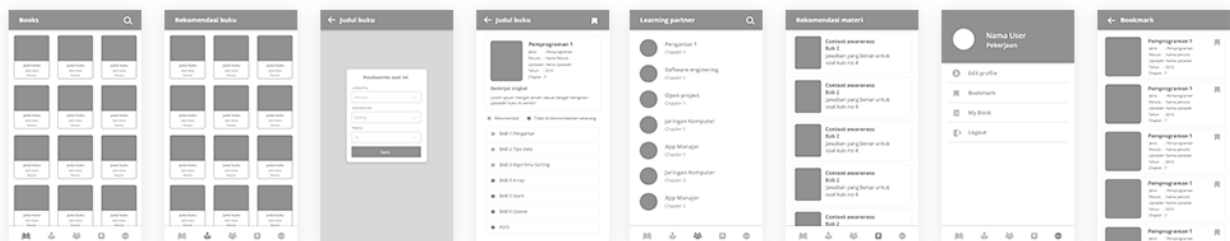


Figure 9. Interactive e-book reader user interface



Figure 10. Prototype interactive e-book reader



Figure 11. Prototype of interactive e-book reader

4. Discussion

After the whole design thinking process is done the next step is data collection and analysis. Data collected from the results of the prototype testing was then analyzed in accordance with what was expected in the preliminary study.

1. Knowing the learning problems experienced by students when using e-books.

From the empathize stage we gathered various problems experienced by students when using e-books as a learning tool namely: (a) Location, time and concentration affect the quality of learning using e-books, (b) book recommendations are needed according to user needs, (c) chapter recommendations are needed according to the user's situation when using e-books, (d) study partners, (e) messages, (f) too much material, (g) quizzes for practice, (h) interactive quizzes, (i) recommendations for suitable material, and, (j) too much and monotonous material. After the determination stage, the four problems with the highest rank are: (a) Required book recommendation feature is appropriate to the user's situation, (b)

required chapter / chapter recommendation feature according to the user's condition, (c) Message feature as a means of discussion with peers, and (d) interactive quizzes with recommended chapter recommendations.

2. Recommend a design model of a learning media in the form of context aware and collaborative mobile learning system.

Based on problems and user-needs gathering at the empathize stage, the researcher recommends a context aware design model and a collaborative mobile learning system. The context aware and the collaborative mobile learning system architecture design consists of three layers: the context sensing layer, the contextual adaptation layer and the application layer. This model is an amalgamation of 4 architectural designs of problems / user-needs compiled into a unified model unit.

3. Knowing the feasibility of the e-book after applying the context aware and collaborative mobile learning system design model.

The test results using the guerrilla method, obtained the following results:

Table 2. Usability test results using the guerrilla method

Task	Score 1	Score 2	Score 3
Task 1 Book registration & recommendations	0	3 (10%)	27 (90%)
Task 2 Books & Recommendations chapter	0	4 (13,33%)	26 (86,67%)
Task 3 Quizzes & Material recommendations	0	7 (23,33%)	23 (76,67%)
Task 4 Study Friends	0	2 (6,67%)	28 (93,35%)
Task 5 Bookmark	0	0	30 (100%)
		10,67%	88,33%

Score 1: The user cannot perform the task
 Score 2: The user can do the task but with a few problems
 Score 3: Users can carry out tasks without problems

From the results of the usability test in table 2, we can see that the easiest assignment is assignment 5 with thirty students able to carry out assignments without problems. The reason why assignment 5 becomes the easiest task to do is that it only presses the bookmark button, so students don't need much effort to complete the assignment.

Task 3 becomes the most challenging task to do even most students can do it without problems. However, compared to other assignments, this task has the highest number of students who cannot perform assignments without problems (seven students). The reason why this task is the most challenging task to do is because it requires two processes. Assignment 3 requires students to work on the quiz until it has been completed until they have obtained true and false grades. The wrong value is used by the system to provide recommendations for the correct answer in the form of appropriate material to students. So students can receive material on the quiz recommendation feature. Because there is no assignment with a score of one, so it can be concluded that this prototype design is feasible to use and understand by users.

5. Conclusion

The application of context aware and collaborative mobile learning system design with this design thinking method is expected to help students in their learning processes, especially in the use of e-books as a learning tool. The use of design thinking methods in developing context aware and collaborative mobile learning systems design model is expected to be able to bridge between the needs of users with the results of products that match their needs. The application of the five stages in design thinking consisting of empathize, define, ideate, prototype, and test can identify learning problems experienced by students so that learning media are developed in accordance with the problems faced. The application of context aware and collaborative mobile learning system design in this study is an example that learning media developed with design thinking methods (from learning problems experienced by students) will also be easy to use by students when learning. Therefore, this becomes an interesting discussion about whether implementing a context aware and collaborative mobile learning system design using design thinking methods for other learning media research will produce the same results.

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