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Development of ETNOCHEM Application for Chemistry Learning with STEAM-2C Approach based on Local Wisdom

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Abstract— **Chemical substances containing complex and abstract concepts make it difficult for students to understand, while the existing teaching media have not been able to be a solution for them until now. The development of technology in the digital era is very rapidly affecting various fields including education, which plays an important role in producing quality human resources with the use of technology, one of which is mobile application. The application of mobile application intended for teachers and students in studying chemistry should be designed in accordance with the needs so that learning can take place, so that the ETNOCHEM application is made. The research method used is qualitative with the development using the System Development Life Cycle (SDLC) method that uses the Waterfall model. The development is carried out with the aim that previously abstract and difficult to understand chemicals can be solved using a combination of graphic objects, audio, visual interesting materials, through projects that will be applied by students. The delivery of the material in it uses the STEAM-2C approach to lift various disciplines and is able to connect local wisdom with science.**

Keywords— *chemistry, Mobile, Education, SLDC, STEAM-2C.*

INTRODUCTION

Currently entering the era of digitalization followed by the development of increasingly rapid technology. The development of this technology can have an impact on various aspects or fields in life, especially in the field of Education [1]. The field of education is now one of the paths that can produce quality resources by transforming from the old way into a way that optimizes the use of technology. The use of this technology can be used as a learning facilitator without limited space, distance, and time [2]. One of the integration between technology and learning in schools is the use of mobile applications.

Mobile application is an interactive learning media that presents learning materials in the form of practical, simple, interesting because it comes with pictures and videos of learning and easy to carry anywhere [3]. The application of mobile application in the field of Education requires a clear development plan so that it can be used well by students or teachers so that learning goals can be achieved. According to research by Sagita et al (2016) states that in the development of mobile applications as a learning medium requires a system Development Life Cycle (SDLC) methodology that uses a Waterfall model [4]. The Waterfall Model is an application development

model that is systematic in building information systems in stages [5]. This Mobile application can help high school students learn more about the concept of the material through interactive learning, one of which is chemistry.

The fact that students find it difficult to understand chemistry because it contains complex and abstract concepts in which there are various reactions combined with mathematical calculations are quite difficult [6]. States that as many as 83.3% of high school students choose to study chemistry using a mobile application because it is packaged interestingly and practically [7]. The existence of chemical applications that combine graphic, audio, visual objects in terms of interesting material content, especially if supported by projects that will be applied by students [8]. One of the educational findings in achieving effective 21st century learning is STEAM-2C (Science, Technology, Arts, Engineering, Mathematics, Culture, and Communication). The benefits of this approach make students able to solve problems better, be creative, innovative, independent, think logically, and collaborate. [9].

The STEAM-2C learning Model is the result of a combination of STEAM with Culture and Communication. In this aspect of culture, it integrates learning with community culture which leads to the potential of local wisdom that has a connection to naturalist intelligence [10]. While the communication aspect integrates learning with verbal representation and linguistic intelligence and interpersonal intelligence are connected with the interaction in the community (society) in solving a problem [11]. The STEAM-2C learning Model has an influential impact on learning motivation, scientific literacy, Higher Order Thinking Skills (HOTs) and Technological Pedagogical Content Knowledge (TPACK) for students [12]. The connection between the mobile application and the STEAM-2C learning model can be a facilitator that accommodates students to increase 21st Century competence in Chemistry learning.

Based on primary data collected by the authors, as many as 75.2% of high school students who filled out the questionnaire, interested in studying chemistry through cultural approaches that have been known to them before. This type of approach is known as ethnoscience where it connects local wisdom with science. Through this application, it can be a place to introduce phenomena that are believed by the community combined with science materials and preserve local wisdom, one of which is the Malang area. One of the chemicals that can integrate with local culture is acid base material. Where the dyes in the process of dyeing batik in it there is an acid-base reaction that will affect the quality of batik. However, unfortunately until now there has been no mobile application, especially acid-base material that integrates local batik wisdom in learning. Therefore, the author sparked an innovation development of ETNOCHEM as a Chemistry learning application based on local wisdom with a STEAM-2C approach that can accommodate increasing 21st Century competence and cultural preservation through chemistry learning.

METHOD

Data Collection Methods

The research method was carried out qualitatively by collecting data through observation, questionnaires, and literature studies. Preparation of research methods based on the preparation of the results of the analysis of the research model to be used. From the results of the selection of system development, the Waterfall model is used. Here's a flowchart of this study:

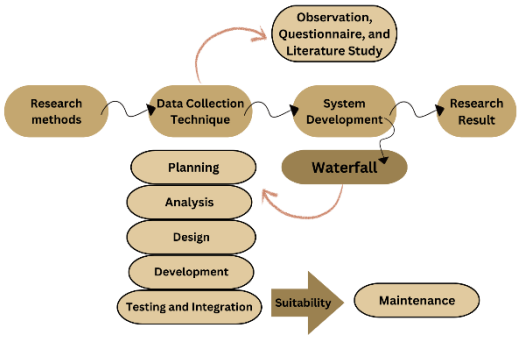

Figure 1. Research Methodology

Information System Development

The development method uses the System Development Life Cycle (SDLC) Framework with a waterfall approach. The Waterfall approach consists of 6 flow stages that run in one direction from the beginning to the end of development (Wiersma, W., 2009). Therefore, the output of the previous stage is the input for the next stage. Waterfall SDLC method to develop a software is shown in the following model illustration:

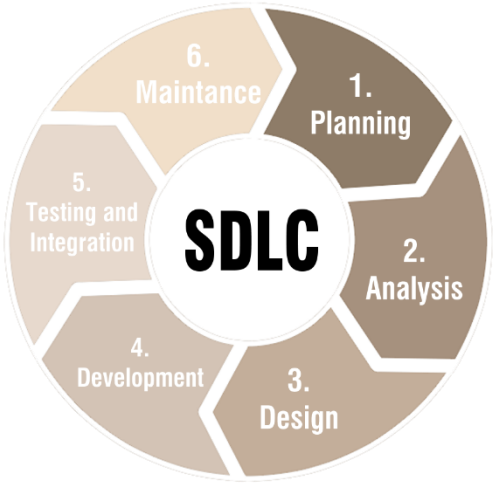

Figure 2. Waterfall SDLC method steps

That the criteria for the SDLC Waterfall method are as follows:

1. Planning, namely identifying and determining the scope that needs to be done in the development, so that the system is more effective and does not shift from its original purpose.
2. Analysis, namely analyzing needs through data collection, which aims to determine the expectations of users related to the application developed.
3. Design, namely the design of the interface so that the system is easy to understand and fun.
4. Development, namely the implementation of a programming language to build the entire system.
5. Testing and Integration, namely testing the system to ensure that the development of the system has met the requirements.
6. Maintenance, which is the application of the system as a whole which involves repair, upgrade, and enhancement activities.

RESULT AND DISCUSSIONS

Learning applications can help facilitate a more interactive and engaging learning process, one area that utilizes this technology is chemistry learning. In the process, the development of ETNOCHEM application for learning chemistry with STEAM-2C approach based on local wisdom is carried out using the System Development Life Cycle (SDLC) Framework method. Stages undertaken for the development of applications ETNOCHEM as follows:

Planning Stage

At the planning stage, the following steps have been taken to plan the development of the ETNOCHEM application:

a. Distribution of questionnaires and field observations: to understand the needs of users in more depth, has been done the distribution of questionnaires to 245 students and teachers in 5 high schools in Malang. From this questionnaire, it was found that 85.7% of students found it difficult to understand chemical concepts, and 72.4% of teachers felt the need for a more innovative and interactive learning approach.
b. Literature study: literature study is conducted to collect information related to the research topic. Data from literature studies show that the implementation of e-learning in education has increased rapidly in recent years. In 2022, a survey by EdSurge showed that about 90% of educational institutions use e-learning platforms [13]. This stage is done by collecting all the information related to the topic being studied from various sources obtained the following results:
    - Information related to E-Learning and applications: literature studies reveal that the use of applications in learning has opened up new opportunities in distance education. Data shows that in 2021, more than 62% of students in various countries used learning applications to support the learning process.
    - STEAM-2C approach in Chemistry learning: based on literature studies, the STEAM-2C approach has been shown to increase student interest in the field of science. Data shows that students engaged in the STEAM-2C approach have better critical ability and creativity [14].
    - Local wisdom in learning: literature studies also indicate that the integration of local wisdom in learning can increase students ' sense of identity and pride in their culture. Data from UNESCO shows that learning programs that incorporate local culture

can improve learning outcomes and student retention [15].

Analysis

In the analysis phase, steps are taken to understand more deeply the needs of the user and the local context to be integrated into the application. The results of the distribution of questionnaires and field observations in 5 high schools in Malang Raya were used to collect information related to user needs and contextual aspects in the development of ETNOCHEM applications.

a. Purpose Of Application

The main goal of the ETNOCHEM app development is to create a Chemistry learning platform that combines the STEAM-2C approach and local wisdom, with a focus on increasing student engagement in Chemistry learning and understanding of chemistry concepts through an interdisciplinary approach. Based on the results of a questionnaire given to 5 high schools in Malang, 72.4% of students expressed interest in using technology in learning.

b. Scope

The scope of application of ETHNOCHEM includes:

- Chemistry learning modules covering key concepts in chemistry relevant to everyday life.
- Integration of local cultural elements and traditional practices in learning, based on the results of field observations in Malang that identify the potential use of natural materials in Chemistry learning.

c. User Requirements

Based on the results of distributing questionnaires to 245 students and 10 teachers in 5 high schools in Malang:

- 85.7% of students find it difficult to understand chemistry concepts
- 70% of teachers feel the need for more innovative and interactive learning approaches

d. STEAM-2C approach and local wisdom

Integration of STEAM-2C approach and local wisdom based on field observation and literature study:

- STEAM-2C approach: literature studies show that this approach can increase students ' interest in science. Based on field observation data, 75% of students showed greater interest when they were given the opportunity to participate in practical and interactive experiments.
- Local wisdom: field observations in Malang Raya revealed various cultural practices and local wisdom that can be integrated in Chemistry learning, such as the use of natural materials in chemical experiments.

Every aspect in this stage is analyzed based on the data from the distribution of questionnaires and field observations, the development of ETNOCHEM applications becomes more targeted and relevant to the needs and expectations of users in Malang. These data provide a strong foundation in determining the objectives, scope, and approaches to be used in the development of ETHNOCHEM applications.

Design

a. User Interface Design (UI/UX): the interface design of the application is created taking into account the principles of user-friendly UI / UX design. The use of images, animations and other visual elements is integrated to maintain user interest and interaction. UI/UX design done through Figma Website

Figure 3. Design Mockup UI ETNOCHEM

b. Integration of local wisdom: the design of the app includes specific modules that integrate local cultural practices. For example, in learning about chemical reactions, users will be familiar with traditional materials used in traditional practices.

c. User interaction: the design of the application ensures active interaction and involves the user in virtual experiments and interactive exercises. Data show that more than 70% of students prefer learning that involves their hands and allows independent exploration.

Development

The development stage is the core of the application development process, where pre-designed ideas and

concepts begin to be realized into real products. At this stage, the software developers are working hard to implement all the previously identified features and functionality. They use a variety of programming languages, frameworks, and development tools to create the code that will form the basis of the application. During the development process, developers work collaboratively to ensure that each feature is implemented correctly and in accordance with the established specifications.

In addition, the development phase also involves unit testing, where each piece of code is checked separately to ensure that they are working correctly. During this process, small problems or bugs can be identified and fixed before reaching the next stage. Developers also focus on optimizing application performance, maintaining security, and ensuring that code is written in a way that is easy to understand and can be changed in the future.

Figure 4. Creating A React Native Project.

In its development, users use a framework called React Native. React Native is a framework for development that is specialized in android, that's why I use this framework. Also, the documentation for React Native is excellent. Setting up a new project can often be a laborious and time-consuming process as problems in the environment often arise. However, thanks to the well-written documentation, initializing React Native is easy, and by providing the target operating system and development operating system on the documentation, a dedicated step-by-step guide page is returned, and in a matter of minutes development can begin [16].

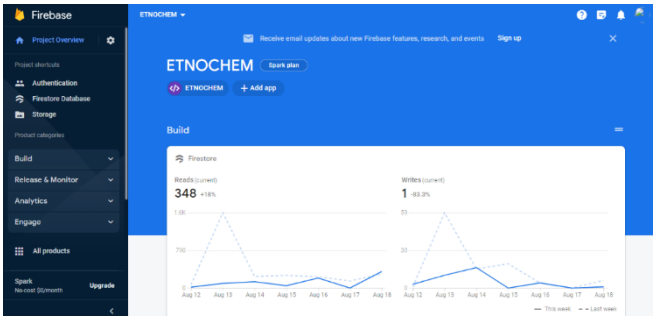

Figure 5. Dasbor firebase ETNOCHEM

ETNOCHEM has only one user role, so all users will login with the same user role. With the CRUD (Create, Read, Update & Delete) required in the Etncohem application using a website database provided by google, namely firebase. Firebase is a service from Google that is used to make it easier for software developers to develop their applications. Functioning as BaaS (Backend as a Service) is a solution offered by Google so that developers can focus on developing the entire application [17]. Firebase already provides complete features in data processing as a backend service, because it has authentication features to process login and register data from users, firestore database to store data from users and storage to store files in various extensions.

Using firebase in React Native requires some setup, such as installing packages using npm commands. In addition, it is also a must have in the ETNOCHEM application also still requires many other package to complete all the features in the application. The full code for ETNOCHEM's react native application is available in the GitHub repository here.

The result of the user interface screen of this application can be seen in the following image.

Figure 6. Loading screen

Figure 7. Login/sign-in screen

Figure 8. Main menu screen

Figure 9. Game screen

Figure 10. Pre-test screen

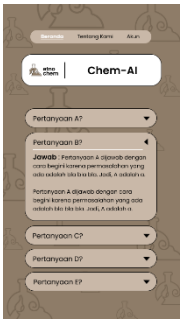

Figure 11. Chem-AI screen

Testing

Blackbox testing is an important approach in testing Android apps developed using React Native. In this stage, the main focus is on the external functionality of the application without considering the details of its internal implementation. This process focuses on testing inputs and outputs, as well as how application components interact with each other. Blackbox Testing focuses on the functional specifications of the software. The Tester can define a set of input conditions and perform tests on the functional specifications of the program [18].

First of all, in blackbox testing, diverse inputs are given to the application to observe how the application responds and produces the appropriate output. For example, various inputs such as user input, touch screen interaction, and input from other hardware are provided to the application. The goal is to ensure that the application responds correctly to each type of input and delivers the output that is expected. A total of 14 features have been developed in the application, the following are tests of some of the main features of the application, module data which can be seen in Table 1.

Table 1. Testing data in the application

Login					
No	**App Features**	**Test Care**	**Expected results**	**Expectation of result**	**Conclusion**
1	Email and password filled	Email (user@gmail.com) Password (123456)	Enter the home page	Enter the home page	success
2	Email and password are filled in, but the password is wrong	Email (user@gmail.com) Password (123456)	Enter the home page	Sorry invalid password	unsuccessful
3	Email and password not filled	Email and password are empty	Enter the homepage	Sorry, please fill in the input completely	unsuccessful
4	Email and password are filled, but the email is incorrect	Email (user@gmail.com) Password (123456)	Enter the homepage	Sorry, invalid email	unsuccessful
Register					
	Email and password filled	Email (user@gmail.com) Password (123456)	Enter the login page	Enter the homepage	Success
	Email and password filled	Email and password are empty	Enter the login page	Sorry, please fill in the input completely	Unsuccessful
Home					
	User presses the menu on the display	Pressing the button	User goes to the desired page	Enter the page you want to go to	success
	User presses other than the menu button	Pressing something that is not a button	User stays on the home page	Stay in home view	Unsuccessful

In addition, in the context of Android apps developed with React Native, blackbox testing also examines the

interactions between React Native components and Android native components. This is important to ensure that the integration between React Native code and Android native code runs smoothly and does not cause performance or compatibility issues.

In blackbox testing, various scenarios that may occur during the use of the application are also tested. These include less common situation testing, boundary condition testing, and error testing as shown in table 1. By testing these various scenarios, the main goal is to identify any bugs, functionality issues, or logic violations that may occur during real use [19].

Overall, a careful testing process has revealed that the application is able to respond well to different types of inputs and produce consistent and expected outputs by testing Table 1. Testing has also successfully identified and addressed a number of functionality issues that may occur during use, including less common situations and boundary conditions. In addition, the test results also provide a positive view regarding the integration between React Native components and Android native components. Both work synergistically, providing a seamless and cohesive user experience. This confirms that development using the React Native framework has succeeded in producing Android applications that are stable, reliable, and responsive to user interaction [20].

These great results from Blackbox testing also give the development team and stakeholders confidence that the app is ready to be released to the public. By ensuring that key functionality has been thoroughly tested and is running properly, the development team can move on to the next steps in the development process, such as rollout, promotion, and continued support [21].

Maintenance

In order to maintain the performance and success of ETNOCHEM applications that use React Native and Firebase as databases, a structured and sustainable maintenance plan needs to be implemented going forward. Maintenance is an important stage to ensure the application continues to meet user expectations and operate effectively [22]. Here are some steps of the maintenance plan that can be run:

1. Regular maintenance: regular maintenance involves regular monitoring of the performance and functionality of the application. The development team must ensure that all features function properly, responsiveness remains optimal, and interaction with the firebase database runs smoothly. This monitoring can involve checking logs and performance analysis to identify potential issues or performance degradation. By understanding usage trends and patterns, the development team can take proactive steps to prevent further problems.
2. Security updates: in an ever-evolving digital world, app security has become of paramount importance. The development team should regularly check and update the react native framework and other components to address their vulnerability to new security threats [23]. Software security updates, including those related to firebase, should be applied regularly to protect user data and maintain the integrity of applications from cyberattack s.
3. Functionality updates: along with the development of user needs and market trends, the application needs to be updated with new interesting and relevant features. The development team should monitor user feedback, identify improvement opportunities, and develop necessary functionality changes. Development of new features should be done carefully, considering the impact on user experience and overall application performance.
4. Performance improvement: performance optimization is a key component in maintenance. By regularly monitoring application performance, the development team can identify areas where performance improvements are needed [24]. This can involve code optimization, data caching, and reducing network load. These efforts will help ensure that app usage remains fluid and efficient, even as the app experiences significant user growth.

By adopting a structured and proactive maintenance plan as outlined above, ETNOCHEM applications can continue to adapt to the changing digital environment and still provide maximum value for users.

CONCLUSION

Based on the analysis of errors to the process of designing and testing applications ETNOCHEM, it can be drawn several conclusions including:

1. The application is intended to address the problems of students in understanding abstract chemistry, it takes learning media that use the use of technology to be easily applied.

2. This application is designed using the System Development Life Cycle (SDLC) development method that uses the Waterfall model in which the material applies the STEAM-2C approach in an effort to improve 21st Century competence and cultural preservation through chemistry learning.
3. Making applications using JavaScript framework, namely react native and database provided by google, namely firebase
4. The application contains chemistry materials and student project support that utilizes graphic, audio, visual objects of interesting material. The use of the application by the admin who provides the material and students as accessors to the material.This section is mandatory to be added to the manuscript to summarize all the discussion and finding.

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