One Tap to Figure the 21st Century Skills of Senior High School Students Based on Experiment Activities in Temperature and Heat Topic

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ABSTRACT

In today's digital era, educators need a quick, easy, and practical tool to figure their students' 21st century skills. With quick result of students' 21st century skill, educator can soon decide appropriate treatment in their next meeting to enhance the skills. The second problem is when we want to figure students 21st century skills based on laboratory activities, not every school has science laboratory. To solve these problems, we created a technology-based assessment media in the form of developing tests using an Android Application to measure 21st century skills (4Cs) based on experimental activities problems for high school students. The test instrument consists of 32 questions to measure 21st century skills based on experiment activities, 16 questions for the sub-material of temperature and expansion and 16 questions for the sub-material of heat transfer based on the rubric developed by Boss (2012). We have created experiment activities videos. Before the 21st century skills test instrument was created in the form of multiple choice, we made the questions in the form of open-ended questions based on experiment activities. Then distributed to students who have received the material. Then, the answers given by the students were analyzed to be used as alternative answers to the multiple-choice test. In this application in each topic there's a link to an experiment video, after the students watch the video, they must answer related to data and activity in the video. After they answer all the questions, the result will show their achievement in each 21st century skills e.g., critical thinking, creativity, communication, and collaboration in related topic. Users can also see the solution of the tests that have been done. After that, the Android Application is reviewed by 3 persons in the field of physics education. All content has run in accordance with expected results or can be called successful. We hope, in the future this Android application can be developed by adding materials and features also fixing existing shortcomings.

Key Words: Android Application, 21st century skills, Experiment Videos and Virtual Laboratory.

1. INTRODUCTION

The implementation of a quality learning process must involve all components including learning, subject matter, learning methods, learning media, teachers, students, environment and evaluation (Zuhri and Rizaleni, 2016). One of the components that support the success of learning is learning media. Listyanto and Munadi (2013) defined learning media as everything that is used to convey messages from the teacher in a

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planned manner so as to create a conducive learning environment. One of the functions of the media in learning activities is to explain the material or physics concepts being taught.

Technology has promising potential in improving education. Technology already has a big role in the implementation of the teaching and learning process, one of which is helping educators and students to interact actively. 21st century skills are skills that a person needs to have, such as critical thinking skill, collaboration skill, communication skill, and creative thinking skill. In addition, 21st century skills can be improved if the learning process is carried out using information and communication technology (Utari, Manopo, Feranie, Prima, & Iswanto, 2020). This is in accordance with what was stated by Anderson (2010: 31-33), that there are four stages of information and communication technology integration, starting from emerging, applying, infusing, and transforming. Now, information and communication technology has become an integral part of individual and group activities as a tool that is used routinely to help learning in the classroom, one of which is through digitizing learning media that can be packaged more attractively and interactively for use (Sugianto, 2013). The use of digital-based learning media has a significant influence on the attractiveness of students to learn the competencies taught and can increase students' motivation and understanding in learning (Zuhri and Rizaleni, 2016). Physics learning should be held interactively which can motivate students to participate actively and build students' independence (Mukarramah et al, 2017). Understanding the concepts, principles and laws of physics through analytical thinking processes, curiosity and scientific processes such as practicum is a demand when studying physics (Maiyena and Imamora, 2020).

Based on the description above, we created a technology-based learning media in the form of developing tests using an Android application to measure 21st century skills (4C) based on experimental activities for students, which is called 4C Digital Pocket or 4CDiPo. This is because Android is currently the most widely owned by the community, as shown in Figure 1.

Figure 1: Android App Users in 2019

In the last decade, online testing has become one of the hottest topics in education. The results of research conducted by Fitriady, Sugiyanto, & Sugiarto (2020: 28) shows that tests conducted online are preferred because they have high accessibility and flexibility, as well as providing fast feedback so as to motivate students. In today's digital era, educators need quick, easy, and practical assessment activities. Therefore, this android application can be an alternative tool for measuring 21st century skills that helps educators and high school science students.

2. LITERATURE REVIEW

2.1 Android Application

The Android system is an electronic device that functions as a mobile device and consists of an operating system, middleware, and key applications released by Google (Tim EMS, 2015). In line with this opinion, Kasman defined Android as a system that can operate various tasks on mobile devices that are touch screen. The use of the android system allows a wider number of users because it is practical and comprehensive, allowing for rapid application development on android devices (Gargenta, 2011). The characteristics of android that are easy to develop and modify make it very appropriate to be used as needed in learning. The increasing use of smartphones among school age makes it potential to develop android

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applications as learning media in schools to achieve national education goals (Fatimah, 2014). The use of android applications in the learning process has a positive impact on students including increasing learning motivation and understanding students' concepts of a material and training students' skills in understanding learning material.

2.2 21st Century Skills

Challenges, problems, life and careers in the 21st century can be successfully faced if we master 21st century skills (Redhana, 2019). According to the National Education Association, 21st century skills include critical thinking and problem-solving skills, namely giving scientific reasons, making decisions, and finding solutions to problems; innovative and creative, namely getting ideas to find solutions to problems using various techniques and achieving real and useful contributions in various fields by conveying creative ideas; collaboration, namely working effectively and systematically with diverse group members, being actively involved in achieving goals by exercising flexibility and awareness, and appreciating and respecting the contributions of each group member; and communicate effectively, namely utilizing various types of media and technology and using verbal, written, non-verbal communication skills in various forms and contexts to convey ideas.

2.3 Experiment Video and Virtual Laboratory

Technological advances have also resulted in laboratory activities being carried out digitally. A laboratory activity can be carried out without laboratory equipment as usual. This can be done by presenting video-based experiment media. The video-based experiment media utilizes computer technology in learning through experiment activities. Saptariana (2013) suggested that experiment videos are an alternative to electronic learning that can contain insight and knowledge about learning materials. With experiment video, students can learn independently and spur them to understand concepts. The activity of conducting digital experiment is also supported by a virtual laboratory. A virtual laboratory is a computer-based media that contains simulations of activities in a physical laboratory. Virtual laboratories are created to illustrate reactions that may not be visible in real situations. This virtual laboratory is quite used to assist the learning process in order to improve students' understanding of the material, and is also suitable for anticipating the unpreparedness of a real laboratory (Sutrisno, 2011).

3. METHODOLOGY

The method used in this research is Research and Development (R&D). According to Borg & Gall (Hanafi, 2017), educational research and development (R&D) is a process used to develop and validate educational products. The steps of this process are usually referred to as the R&D cycle, which consists of studying research findings pertinent to the product to be developed, developing the products based on these findings, field testing it in the setting where it will be used eventually, and revising it to correct the deficiencies found in the field-testing stage. In more rigorous programs of R&D, this cycle is repeated until the field-test data indicated that the product meets its behaviorally defined objectives. This R&D research resulted in a product in the form of an android-based application to measure student's 21st century skills based on experimental and virtual laboratory activities on temperature and heat topics, which we named 4C Digital Pocket or 4C DiPo. The development model that we used in this research is the ADDIE development model. There are five main stages in the ADDIE development model, namely analysis, design, development, implementation, and evaluation, as shown in Figure 2.

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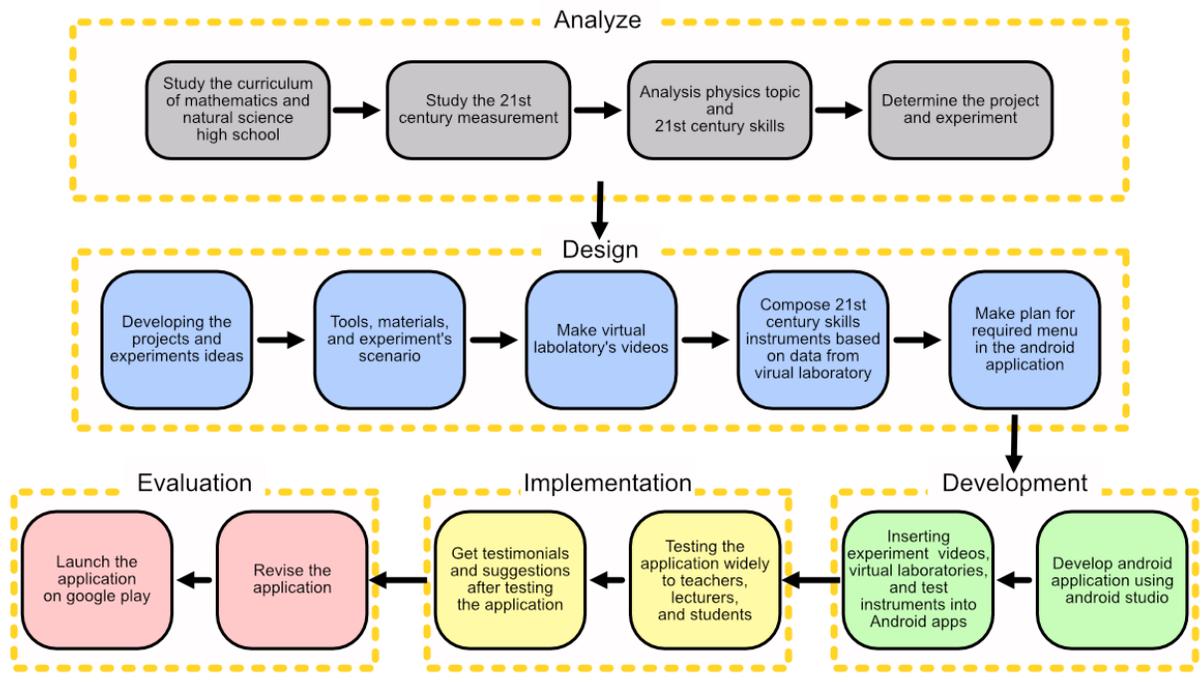
Figure 2: Application Development Steps

The analysis phase is carried out by means of a literature study from reliable research and articles. The content in this application is designed and made as good as possible to be easily understood by users. The test instrument consists of 32 questions to measure 21st century skills based on experiment activities, 16 questions for the sub-material of temperature and expansion and 16 questions for the sub-material of heat transfer based on the rubric developed by Boss in 2012. We have created experiment activities videos too. Before the 21st century skills test instrument was created in the form of multiple choice, we made the questions in the form of open-ended questions based on experiment activities. Then distributed to students who have received the material. Then, the answers given by the students were analyzed to be used as alternative answers to the multiple-choice test. In developing the application, the important point that we consider is that the application must be easily accessible and easy to use. 4C Dipo Apps created on Android Studio 2020.3.1. The application is tested from 11th-21st October 2021 and has been revised since November 2021.

4. RESULT AND DISCUSSION

4.1. Simulation of the Android Application

4.1.1 The Home Menu

The home section consists of the logo, subject, year of manufacture, and buttons that can be pressed by the users to enter the topics of temperature and expansion, conduction heat transfer, help, and about this application. This is as shown in Figure 3 and the home menu test results can be seen in Table 1.
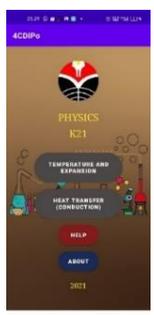
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Figure 3: Display of the Home Menu

Table 3 Home Menu Test Results

Details and Test Results	
Input	Users must press the icon of this application to open the home menu
Expected Results	Showing logo, subject, year of manufacture, and buttons that can be pressed by the users to enter the topics of temperature and expansion, conduction heat transfer, help, and about this application
Test Result	Successed

4.1.2 Temperature and Expansion, Conduction Heat Transfer Menu

When pressing this menu, users can see a display consisting of buttons that can be pressed by the users to enter the video menu of experiments, virtual laboratory, and 21st century skills tests. This is as shown in Figure 4 and the temperature-expansion and conduction heat transfer menu test results can be seen in Table 2.
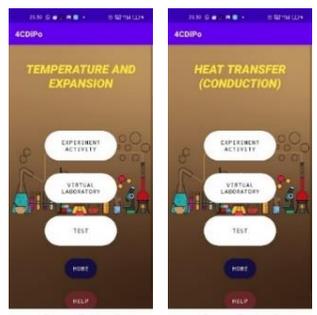

Figure 4: Display of the Temperature and Expansion, Conduction Heat Transfer Menu

Table 2 Temperature and Expansion, Conduction Heat Transfer Menu Test Results

Details and Test Results	
Input	Users must press the temperature and expansion or conduction heat transfer button on the home menu
Expected Results	Showing buttons that can be pressed by the users to enter the video menu of experiments, virtual laboratory, and 21st century skills tests
Test Result	Successed

4.1.3 Experiment Activity Video Menu

Users can press the experimental activity video menu which will be directly connected to YouTube. To view the full screen display, the user can press the   button. To turn on subtitles or captions, users can press the CC button. To watch video, users can press the play button. To speed up the video, users can press the right side of the screen twice. To repeat, the user can press the left screen twice. This is as shown in Figure 5 and the experiment activity video menu test results can be seen in Table 3.
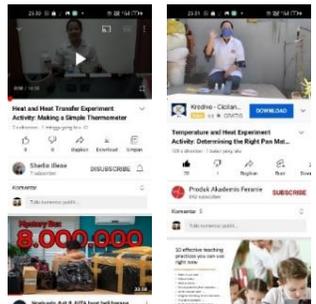

Figure 5: Display of the Experiment Activity Videos Menu

Table 3 Experiment Activity Videos Menu Test Results

Details and Test Results	
Input	Users must press the experiment activity videos button
Expected Results	Showing experiment videos connected directly to YouTube
Test Result	Successed

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4.1.4 Virtual Laboratory Menu

Users can also press the virtual laboratory button that will connect directly to the wolfram web. Users are advised to use supported browsers such as Chrome, Edge, Firefox, and Safari. For temperature and expansion virtual laboratory, users can choose the available thermometer filling fluids, such as fresh water, seawater, acetone, ethanol, and methanol. Users can move forward and backward by shifting to change the fluid mass. Users can move forward and backward by shifting to change the temperature of liquid. After that, users can get heat released. For conduction heat transfer virtual laboratory, to see the process of the melted wax, users can move forward and backward by shifting the heating time or by pressing the button plus above the simulation. This is as shown in Figure 6 and the virtual laboratory menu test results can be seen in Table 4.
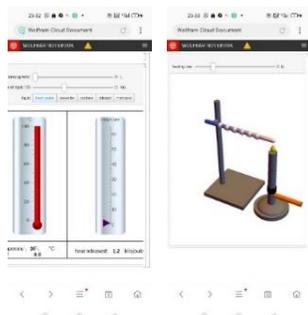

Table 4 Virtual Laboratory Menu Test Results

Details and Test Results	
Input	Users must press the virtual laboratory button
Expected Results	Showing virtual laboratory connected directly to wolfram web
Test Result	Successed

Figure 6: Display of the Virtual Laboratory Menu

4.1.5 21st Century Skills Tests Menu

After watching the experiment activity video and the virtual laboratory, users can answer 21st century skills tests related to the data and activities in the video. The test consists of 16 multiple choice questions on each topic, temperature and expansion and conduction heat transfer. Next, users can press the submit button when they have finished the test. This is as shown in Figure 7.
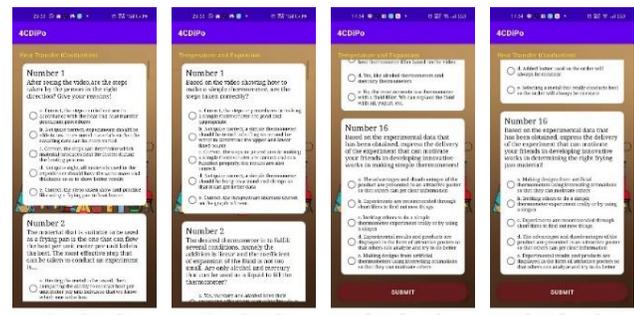

Figure 7: Display of the 21st Century Skills Tests Menu

The 21st century skills tests menu test results can be seen in Table 5.

Table 5 21st Century Skills Tests Menu Test Results

Details and Test Results	
Input	Users must press the 21st century skills tests button
Expected Results	Showing the test consists of 16 multiple choice questions on each topic, temperature and expansion and conduction heat transfer. Users can press the submit button when they have finished the test
Test Result	Successed

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4.1.6 Final Score Menu

After pressing the submit button, users can see the final score of the questions that have been answered. This is as shown in Figure 8 and the final score menu test results can be seen in Table 6.

Figure 8: Display of the Final Score Menu

Table 6 Final Score Menu Test Results

Details and Test Results	
Input	Users must press the submit button
Expected Results	Displays the final score of the questions that have been answered. Users can press the button to view scores for each 21st century skill
Test Result	Successed

4.1.7 View K21 Score Menu

Users can press the button to view scores for each 21st century skill, namely critical thinking, collaboration, communication, and creativity. After that, the user can return by pressing the home button or press the solution button to get explanation of each question. This is as shown in Figure 9 and the view K21 score menu test results can be seen in Table 7.

Figure 9: Display of the View K21 Score Menu

Table 7 View K21 Score Menu Test Results

Details and Test Results	
Input	Users must press the view K21 score button on the final score menu
Expected Results	Displays scores for each 21st century skill, namely critical thinking, collaboration, communication, and creativity. Users can press the solution button to get explanation of each question
Test Result	Successed

4.1.8 Solution Menu

Users can press the solution button to get explanation of each question so that they can learn from the mistakes that have been made when answering the test. This is as shown in Figure 10 and the solution menu test results can be seen in Table 8.
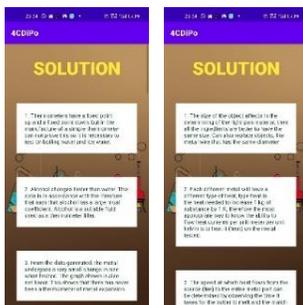

Figure 10: Display of the Solution Menu

Table 8 Solution Menu Test Results

Details and Test Results	
Input	Users must press the solution button on the view K21 menu
Expected Results	Showing the explanation of each question so that they can learn from the mistakes that have been made when answering the test
Test Result	Successed

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4.1.9 Help Menu

Users can press the help button, if they find it difficult to run the application, it consists of explanation on each menu and an e-mail that can be contacted for complaints. This is as shown in Figure 11.

Figure 11: Display of the Help Menu

The help menu test results can be seen in Table 9.

Table 9 Help Menu Test Results

Details and Test Results	
Input	Users must press the help button
Expected Results	Displays the explanation on each menu and an e-mail that can be contacted for complaints
Test Result	Successed

4.1.10 About Menu

Users can press the 'about menu' button to get information about the Android application that is being used. This is as shown in Figure 12 and the about menu test results can be seen in Table 10.

Figure 12: Display of the About Menu

Table 10 About Menu Test Results

Details and Test Results	
Input	Users must press the about button on the home menu
Expected Results	Showing the information about the Android application that is being used.
Test Result	Successed

4.2 Testimonials from Users

Testing by users of the 4CDiPo was carried out by taking reviews from 3 users who run the 4CDiPo application. We analyze the feedback provided with the following stages: providing and explaining the Android application that has been created, conducting interviews to get feedbacks, interviews transcript analyzed by reducing unnecessary things and then writing down the conclusions. From the results of interviews with 3 people in the field of physics education, the Android application is very useful for students in senior high school to understand and explore the concepts of physics in temperature and heat transfer topics. Experiments made are very easy to understand and use with easily available tools. The questions given are also very challenging. During the pandemic, students didn't get to do practicum in the laboratory, so they only studied the theory presented by teacher. Moreover, there is already explanation in it for each

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item of the question that can make users understand the meaning of 21st century skills and help students learn better. Anyway, it's very complete and cool.

4.3 Comparison with Other Studies

Research by Mubarok (2021) shows android app development that focuses on HOTS assessments based on Bloom's taxonomy. We developed the study by focusing on 21st century skill assessments complemented by experimental videos because students did not get experiments in the lab that were never done during pandemic times. Based on previous studies conducted by Salsabila (2021), there are some differences from the content and appearance of Android applications created. Experiment videos are inserted into the application so that later the size of the downloaded application will be large. We connect it directly to YouTube by using a link so that the app size is only 6 MB. There are additional contents in the applications we create, such as virtual laboratories and discussions that are useful for users.

5. CONCLUSION AND RECOMMENDATION

The Android application we created can be one of the applications that help teachers in the process of assessment quickly, easily, and practically by equipping experimental videos that are easily accessible and understood. All content has run in accordance with expected results or can be called successful. We hope, in the future this Android application can be developed by adding materials and features also fixing existing shortcomings.

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