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*Research Article*

# Developing Gen-21cs on smartphone to cultivate the 21st-century skills on biology teacher candidates

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ABSTRACT

The accessibility of learning media is one of the determining factor of student skills in dealing with the 21st-century demands. This study aimed at developing the online-discussion-forum-based Gen-21cs application. This Design Development Research (DDR) used the Richey and Klein Model which comprised of six phases, namely, 1) identifying the problem by determining learning indicators and supporting literature, 2) determining the purpose of development, 3) making the design and development of tools 4 ) approve device testing, 5) try device test results and 6) communicate device test results. The data gained were analyzed using descriptive qualitative. The development results showed that the Gen-21cs application can be used in learning process and facilitated students to conduct online discussion. Furthermore, the validation results indicated that the media was feasible to use with 'very good' category.



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## INTRODUCTION

Advances in cellular technology have influenced the teaching and learning process at various levels of education (Bai, 2019). Learning using mobile technology has become a trend (Anohah, Oyelere, & Suhonen, 2017) as a form of response to the needs of Industry 4.0 where humans and technology are aligned to the new possibilities (Hussin, 2018). For example, learning using mobile devices and learning that is carried out in a mixture context (Burden & Kearney, 2016). Mixed learning includes blended learning (Dung & Fatmawati, 2018) or online (Tucker, YoungGonzaga, & Krause, 2014).

The learning process is an interaction between learners and educators; this interaction is needed in online learning (Abrami, Bernard, Bures, & Borokhovski, 2011). Learning that is carried out either by blended or online is a future trend. Various needs are adapted to learning indicators in designing learning devices using e-

learning technology so that learning outcomes are more effectively achieved (Doering, Veletsianos, Scharber, & Miller, 2009; Gros & García-Peñalvo, 2016; Shai & Shwartz, 2011).

A smartphone is a cellular telephone device that is almost owned by everyone. Smartphone functions have also developed under the development of information technology. Smartphone-based online learning activities need to be applied to prospective teacher students considering the function of educators as the frontline in the educational process and seeing learning trends in the industrial era that emphasize students' ICT abilities (A. Brown & Green, 2018; Feola, 2016). Development of instructional design in smartphone-based learning media needs to be done (Nuray, Karademirci, Kursun, & Cagiltay, 2012) so that it can be used in blended learning (Dung & Fatmawati, 2018; Gedik, Kiraz, & Ozden, 2013) and can improve the cognitive abilities of the online learning community (Akyol & Garrison, 2011). Therefore, further development is needed, so that online applications can facilitate a variety of skills in the Indonesian 4.0 era and promote the true nature of learning, namely the interaction between teachers and students (Abrami et al., 2011; L. Brown, 2014).

Learning activities are progressive processes of cognitive and skill aspects in a 21st-century curriculum domain. The emphasis of this curriculum is on providing the 21st-century skills to students in the learning process; hence, learning is expected to be more meaningful and able to answer future needs. Learning activities have to strengthen the attitudes, strategies and behavior of students that keep them motivated to become a generation of long life learners, with an ongoing curiosity, and have the capacity to improve the skills needed. The skills of the 21st-century competencies include critical thinking, creative and innovative thinking skills and communication and collaboration skills (Donovan, Green, & Mason, 2014).

Genetics is a compulsory subject in undergraduate education both in the Biology science program and in Biology education. This subject has a rapid research development, especially research in the field of molecular genetics. Genetic learning is widely applied using analogies (Maryuningsih, Hidayat, Riandi, & Rustaman, 2018), so that students' reasoning is expected to support better genetics comprehension, given the abstract concept of genetics. The rapid development of the Genetics field is marked by the abundance published research in the field of genetics. In genetic learning, in addition to the application of analogies in learning, it is also necessary to discuss several case studies in socio-scientific issues and the use of published genetic research results (Alozie, Eklund, Aaron, & Krajcik, 2010), which are available in various articles from various journals as reference sources.

The 21st-century learning that emphasizes learning assisted tools or media (Doering et al., 2009), allows the use of the internet as learning materials and resources for students who then discuss it in an online discussion forum. The discussion forum can facilitate students to practice 21st-century skills, one of which is critical thinking skill (Maryuningsih, Hidayat, Riandi, & Rustaman, 2019). The characteristic of learning in the 21st-century is ICT-based learning by utilizing various internet facilities as learning resources (Kivunja, 2015). For this reason, it is necessary to develop smartphone-based applications. The smartphone-based application design will contain various tools and content that support the learning process. ICT-smartphone based learning can be applied in the learning process with online discussion and is a learning process that facilitates students in developing thinking processes in a discussion forum for teacher candidates utilizing mobile learning (Alasmari & Zhang, 2019; Anohah et al., 2017; Bai, 2019).

Mobile learning in a learning community needs to be designed to develop 21st-century skills (Y Maryuningsih et al., 2019). The development of mobile learning has been carried out by Garvey (2015) with the design of games for learning, Elias (2010) by developing Moodle, as well as Shen, Wang, Gao, Novak, & Tang (2009) by developing direct mobile videos and learning evaluations. Furthermore, Other research states that the online discussion model has a very positive impact on students in studying biology in general and some specific material such as bioinformatics (Pedrosa-de-Jesus & Moreira, 2012;Ding et al., 2014). However, research has not been carried out on the development of special media about genetic material, and because the genetic material is known more difficult to understand to student so is needed more spaces for discussion forum. Then, this study was really important, due to the aim of this study was to facilitate the student by having an online discussion forum and to enhance the understanding of student about the genetic material.

## METHOD

This research was a development study to make a smartphone-based application by implementing online discussion forums on Genetics lectures. The approach was to use the Design Development Research (DDR). The DDR was considered appropriate by considering its pragmatism in testing theory and validating practicality. In addition, it was explained that DDR could be seen as a way to establish new procedures, techniques, and tools based on the analysis of specific needs (Richey & Klein, 2014) determined by the developer. The application development research of Gen-21cs implemented DDR approach through six stages, namely (1)

identifying the problem by determining learning indicators and supporting literature, (2) determining the purpose of development, (3) designing and developing devices by; a) creating a Gen-21cs application design, b) determining the software to be used, c) preparing a Gen-21cs application storyboard and d) requesting expert validation, (4) testing the device, (5) evaluating the results of the device trial and (6) communicating the results of the device trial. The design flow of Gen-21cs application development is illustrated in Figure 1.

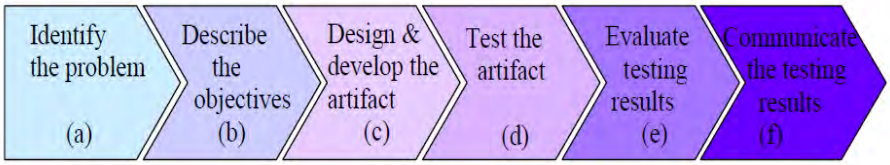


Figure 1. Application development flow of Gen-21cs (Adaptation from Ellis & Levy, 2010)

The objective of this research was the development of the Gen-21cs application. The application that has been developed was then validated by a media expert and a material expert to determine the appropriateness of the application that will be used in the online learning process. Then the application was limitedly tested to 104 teacher candidates at one of the tertiary institutions in the province of West Java through online discussion forum learning. The forum was divided into three online discussion groups to get participants' responses to the ease of use and operation of the application in the learning process. The next step was to improve the appearance and tool facilities in the Gen-21cs application according to the validator's suggestion. This application was developed in the Genetics course. In the application, three large groups were generated into online discussion forums. Data collection techniques and data analysis were carried out following the stages of development which included descriptive and qualitative analyses. Data collection techniques are described in Table 1.

**Table 1**. Data collection technique and analysis

| No | Data | Indicator | Instrument | Data analysis |
|---|---|---|---|---|
| 1 | Expert validation | Media and content | Gen 21cs eligibility | Descriptive qualitative |
| 2 | Participant responses | Operational practicality | | Descriptive qualitative |

## RESULTS AND DISCUSSION

In developing and designing group discussions based on an online learning application (mobile learning) conducted in general with both large and small group designs, Gen-21cs Application Development can use DDR design. According to Richey and Klein (2014), the aim is to equip 21st-century skills with an online discussion forum set up in smartphone. The application development of Gen-21cs with the DDR approach was conducted in six stages, namely (1) identifying the problem by determining learning indicators and supporting literature, (2) determining the purpose of development, (3) making the design and development of the device (4) testing the device, (5) evaluating the results of the trial devices and (6) communicating the results of device trials. The stages of making a Gen-21cs design were reduced to 10 stages of the development which are outlined in Table 2. Gen-21cs application contains some chat facilities and 21st-century skills content. The facilities embedded in the Gen-21cs application include chats that are divided into large groups that hold several students in each class, and then in each group, they are subdivided into three small groups.

This grouping can be used in assignments, learning discussions and work assignments discussions. Development was done first by creating an application development flowchart and an operational flow using the Gen-21cs application. The following is a flowchart for the implementation of the Gen-21cs application that applies an online discussion forum, which is described in Figure 2.

Figure 2 indicates that the mobile learning process required three stages of learning consisting of an introduction, preparation, and implementation stages. These three stages of learning were sequences of activities using the Gen-21cs application. In the introduction activity, participants were introduced to the Gen-21cs application in the mobile learning process and then participants were divided into three large groups. The activity at this stage included preparing participants for learning that focuses on online discussion forums. Participants gave responses, comments, and opinions from several discussion themes conducted online. Figure 2 also shows the division of participants' groups in carrying out the learning process which was divided into three large units, namely unit 1 Mendel and the idea of genes and the basis of chromosomal inheritance, unit 2 consisted of the basic molecular inheritance of traits and gene expression: from genes to proteins, and units 3 observed the regulation of gene expression, viruses, and biotechnology.

**Table 2.** Development stages of Gen-21cs application

| Stages | Work details | Descriptions |
|---|---|---|
| 1 | Designing the storyboard of Gen 21 cs. | Designing the storyboard based on the design principle. |
| 2 | Setting up the web page of Gen-21cs (dashboard) | Designing web pages for Gen-21cs (dashboard). |
| 3 | Developing Gen 21cs application for smartphones | Developing the Gen 21cs applications by integrating learning content into design templates |
| 4 | Uploading and publishing Gen 21cs website. | Uploading and publishing websites on internet servers and testing applications. |
| 5 | Evaluating the application and dashboards to experts | Conducting the pre-formative evaluation with media experts and material experts. |
| 6 | Revising the app display of Gen 21cs | Revising and modifying the development process based on feedback and responses. |
| 7 | Testing a Gen 21cs device or application. | Conducting the 1st trial of Gen-21cs application for lecturers and students as actual users. |
| 8 | Revising the design and its development | Revising and modify the development process based on feedback and responses. |
| 9 | Conducting an extensive trial as an implementation of online learning | Evaluating the extensive trial of Gen-21cs with students and lecturers as real users. |
| 10 | Implementation evaluation. | Conducting data analysis and reporting on the design and development process. |

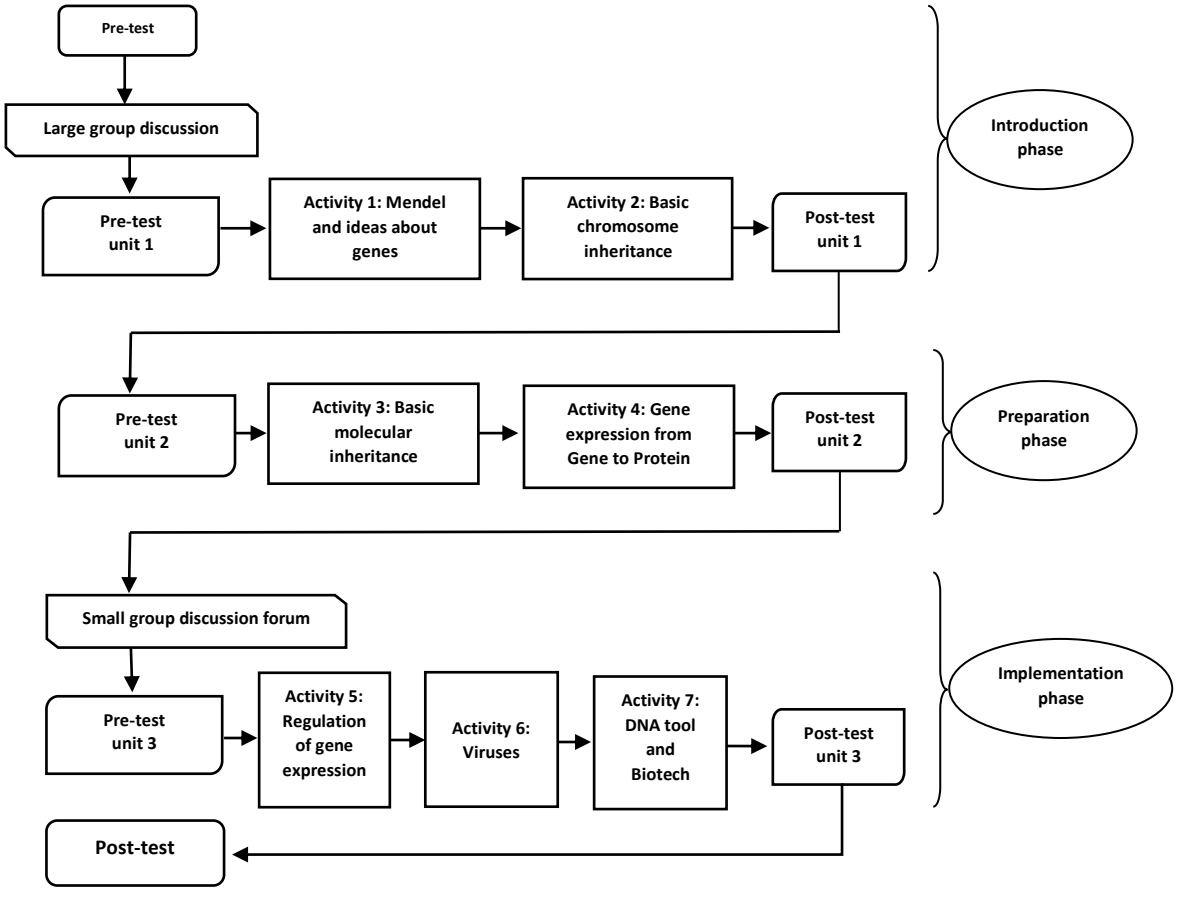


**Figure 2.** Flowchart of Gen-21cs application implementation

Figure 2 also suggests that the Gen-21cs application required several tools to support the mobile learning process. Some of the tools needed include teaching materials, assignments and formative evaluations. The tool facilities in the Gen-21cs application were adjusted to the needs, so the tool facilities contained in the Gen-21cs application had to meet all the needs of the learning process. Those needs were facilitated by the Gen-21cs application and were included in the Gen-21cs application display on the smartphone depicted in Figure 3.

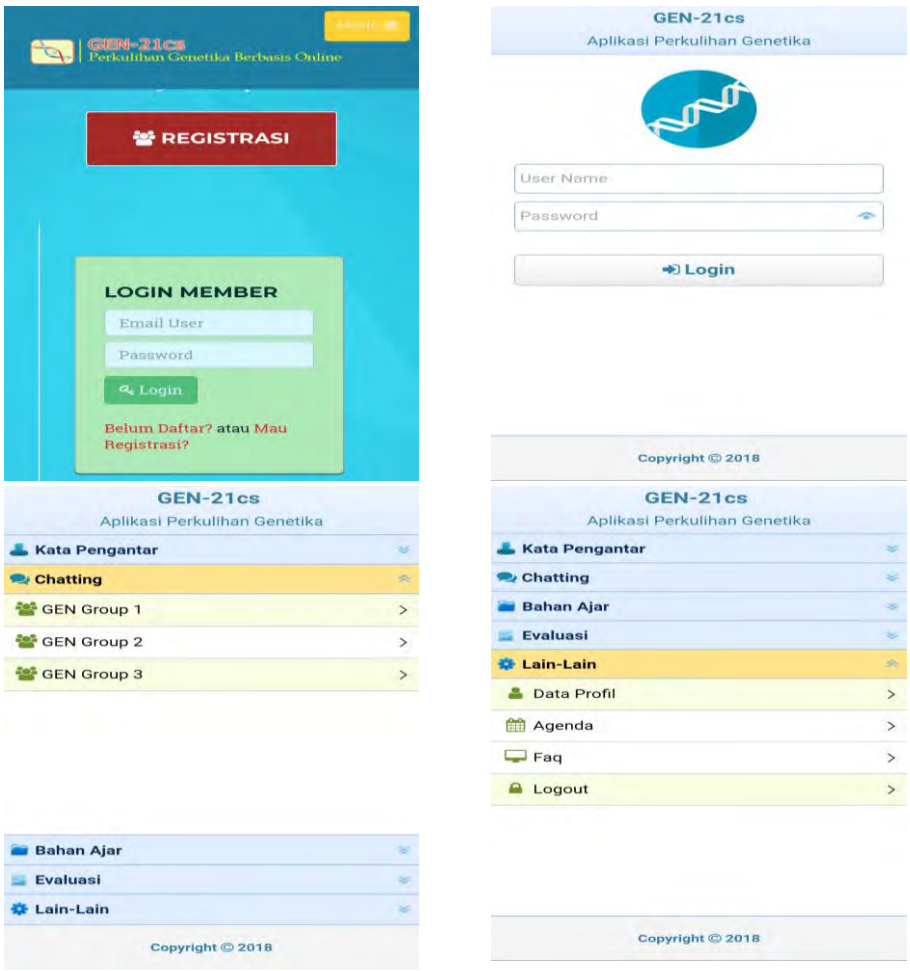


**Figure 3.** The display of Gen-21cs on smartphone

Figure 3 signifies that the online discussion forum facility was available in the chat tool, which was divided into three main groups and each group was further divided into three small groups called classes. In the chat tool there were several discussion groups. Gen-21cs application was then validated by several genetic content experts and media experts. The following are the results of the validation of media experts and genetic content experts to Gen-21cs applications and Gen-21cs application user responses in the learning process, which were also described in the following Tables 3, Table 4 and Table 5.

**Table 3.** Results of media expert validation results on Gen-21cs applications

| No | Indicators | Expert 1 | Expert 2 | Expert 3 | Average | Criteria |
|---|---|---|---|---|---|---|
| 1 | Completeness of learning devices on Gen-21cs application | 3.7 | 3.8 | 3.7 | 3.73 | Very good |
| 2 | Gen-21cs application facilitates class and small group discussion forums. | 3.8 | 3.9 | 3.8 | 3.83 | Very good |
| 3 | This application facilitates Website links and video links both in the content of teaching materials, as well as discussion forums and assignment comments columns. | 3.5 | 3.7 | 3.8 | 3.67 | Very good |
| 4 | Gen-21cs application contains a variety of material content, videos and evaluation tools. | 3.7 | 3.6 | 3.8 | 3.70 | Very good |
| 5 | There is ease in operating Gen-21cs application on an Android type smartphone. | 3.7 | 3.8 | 3.7 | 3.73 | Very good |
| 6 | Gen-21cs application facilitates task uploads and comment columns as task feedbacks. | 3.8 | 3.8 | 3.9 | 3.83 | Very good |

In the chat facility, an online discussion with several discussion themes was adjusted to the learning units. The theme of discussion in each week changed according to the learning objectives. In this discussion forum, instructors or students were free to apply models, strategies or approaches in the learning process. The

instructor could also determine the members of each discussion group according to the purpose of the group division. The appearance of an online discussion forum on the Gen-21cs application has been described in Figure 4.

**Table 4.** Genetic content expert validation results in Gen-21cs application

| No | Indicators | Expert 1 | Expert 2 | Expert 3 | Average | Criteria |
|---|---|---|---|---|---|---|
| 1 | Completeness and accuracy of the learning device in Gen-21cs application and its suitability with the learning indicators. | 3.8 | 3.7 | 3.8 | 3.77 | Very good |
| 2 | Gen-21cs application facilitates class discussion and small group forums as a home of online learning process | 3.9 | 3.8 | 3.5 | 3.73 | Very good |
| 3 | This application facilitates Website and video links, both in the content of teaching materials as well as discussion forums and assignment comment columns. | 3.7 | 3.8 | 3.7 | 3.73 | Very good |
| 4 | Gen-21cs application contains a variety of content, videos and evaluation tools that fit the learning objectives. | 3.6 | 3.8 | 3.7 | 3.70 | Very good |
| 5 | Gen-21cs application supports task uploads and comment columns as task feedbacks. | 3.8 | 3.7 | 3.8 | 3.77 | Very good |

**Table 5.** Participants' responses on the use of Gen-21cs application.

| No | Indicators | Group 1 | Group 2 | Group 3 | Average Score | Criteria |
|---|---|---|---|---|---|---|
| 1 | Ease of operation on an Android type smartphone. | 3.8 | 3.7 | 3.7 | 3.73 | Very good |
| 2 | Completeness of learning devices | 3.9 | 3.8 | 3.8 | 3.83 | Very good |
| 3 | Facilitating class and group discussion forums. | 3.7 | 3.8 | 3.5 | 3.67 | Very good |
| 4 | Facilitating website and video links both in the content of teaching materials, as well as discussion forums and assignment comment columns. | 3.6 | 3.8 | 3.7 | 3.70 | Very good |
| 5 | Displaying a variety of learning material content, videos and evaluation tools | 3.8 | 3.7 | 3.7 | 3.73 | Very good |
| 6 | Facilitating task uploads and comment columns as task feed backs. | 3.8 | 3.9 | 3.8 | 3.83 | Very good |

In the chat view in Figure 4, the instructor could equip and provide ample practices of 21st-century skills by using sentences to develop critical, creative thinking processes or problem-solving in online discussion activities. In the trial application of Gen-21cs which was conducted on 104 students of practice teachers who took the subject of genetics, practice teachers' responses on various themes discussed in online discussion forums were positive. Students not only praised genetically content but also developed thought processes that could be directed to the implementation of 21st-century skills.

The development of the Gen-21cs application using the DDR was considered appropriate to develop mobile learning media to support the learning process in the classroom. This application has a discussion facility, teaching material posts, assignments or project assignments and evaluations that are embedded in one application. This media makes it easier for educators to make recordings of student learning outcomes. The instructor is facilitated in making digital recordings of students' learning achievements, as all learning processes are recorded in the application informative evaluation results and participant responses in discussion forums.

The use of Gen-21cs application in the learning process is a form of ICT-based learning because it uses information technology in its application. In the general learning process, students use a variety of information technology learning facilities when they respond in discussion forums. In the process of mobile learning, instructors can apply several approaches and learning models that provide students with 21st-century skills. Gen-21cs mobile application is a form of learning medium, a tool that can be used both in ordinary learning or distance learning. This mobile learning can be done at any time, without limitation of place and time. In the application of the Gen-21cs discussion forum, the instructor and participants can list the website for the source of the response and the link can be directly checked or seen by other participants, so that the discussion forum is an active discussion process, fellow participants can respond to each other, refute at a time without waiting for other participants finished giving responses like in ordinary discussions. This means that online discussion forums can increase active student participation, so discussions are no longer monopolized by only a few students.


**Figure 4.** The display of the online discussion forum

Learning in either online or offline context requires a design or a framework (Bai, 2019) to develop learning media in the form of games (Garvey, 2015), Moodle (Elias, 2010), and videos and their evaluation forms (Shen et al., 2009). The development of learning media needs to be done to help the learning process. In its development, a developmental design is needed. The design used in developing this media or tool is the DDR, where DDR is the seen as the right approach, given the practicality in its goals set up (Ellis & Levy, 2010). The design making for learning media in an online-based community requires several attributes or tools in its application. In making Gen-21cs that is intended for teacher candidates, information technology (A. Brown & Green, 2018) is needed for professional development, so that the pedagogical knowledge framework and content are facilitated in the mobile application (Doering et al., 2009). Implementation of the application as a learning process is considered as the learning process of prospective teachers.

The online application of Gen-21cs is mentioned to be a present and future trend, where the use of information technology in the learning process facilitates the ability of e-learning technology in the use of machine-based application technology (Gros & García-Peñalvo, 2016; Shai & Shwartz, 2011). The implementation of Gen-21cs media is seen as being able to increase online learning activities, this can be seen from students' perceptions about this application which according to them can improve the quality of online learning (A. Brown & Green, 2018), digital literacy and positive perspective of new technology use in the learning process (Feola, 2016). Digital capability with the use of the Gen-21cs application is one of the literacy products in the 21st-century (Pilgrim, Elda, & Martinez, 2013; Stevens, 2012). This is deemed able to improve cognitive abilities as a result of learning (Akyol & Garrison, 2011) in the community of both online and blended learning.

Genetic learning in the 21st-century presents its challenges (Alozie et al., 2010), where the use of classrooms or forum for project-based learning can improve the quality of learning. Gen-21cs application that has been developed is used as a Genetic learning media based on online discussion forums. The forum functions to design learning by utilizing information technology as much as possible and by developing pedagogical competencies and creative content.

This mobile learning does not merely effective in distance education but also learning in the classroom to improve the recording of student interactions in the learning process (Abrami et al., 2011). Gen-21cs application can develop students 'innovation abilities through creative lecturing assignments, as well as comments and responses to friends' posts. This ability is a configuration map in learning in the 21st-century (Donovan et al., 2014), namely equipping collaborative problem-solving abilities and strategic learning skills with digital literacy (A. Brown & Green, 2018; Häkkinen et al., 2017). This online group-based discussion application supports the creation of social networking activities in the learning process (B & Boholano, 2017).

## CONCLUSION

The development of Gen-21cs learning applications on smartphones based on online discussion group forums was carried out to increase student's activity in learning that can equip 21st-century skills. The DDR approach was chosen because of its practicality. DDR includes stages: 1) identifying the problem by determining learning indicators and supporting literature, 2) determining the purpose of development, 3) making the design and development of the device 4) testing the device, 5) evaluating the results of the device trial and 6) communicating the test results in the trial of the device.

The study suggested that the application of Gen-21cs can be used in the learning process. Gen-21cs application, not only contains learning material and evaluation tools, but also a discussion group interaction facility both in large and small groups. Online discussion group forums on chat facilities allow the development of 21st-century skills, such as digital literacy and other higher-order thinking skills (HOTS). The broad application of Gen-21cs can be used to measure some 21st-century skills in a well-planned and developed learning context.

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