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Developing Instructional Media Android-Based for Building Computational Thinking Skills for High School Students

Pengembangan Media Pembelajaran Berbasis Android untuk Membangun Keterampilan Berpikir Komputasional Siswa SMA

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Life in the 21st century is characterized by exponential changes that lead to increasingly complex problems. This condition underlies current education directed at equipping learners with problem-solving skills. Score of PISA's test for Indonesia in 2018 revealed that students' reasoning abilities are low and this condition is urgent to rectify immediately. Problem-solving abilities can be developed by improving computational thinking skills. Computational thinking is incorporated into Informatics subjects starting in 2021. Instructional media to develop computational thinking skills is still lacking even though the need is very urgent so that students' problem-solving skills can develop better. The provision of android-based instructional media in digital and internet era is important as a solution so that the quality of student thinking is better. This research aims to product android-based instructional media to improve computational thinking skills. The product is developed by R and D methods, and by using ADDIE Model. Research instruments were questionnaires and learning outcome tests, which were used to measure the feasibility of media from experts and the effectiveness of product. Data analysis techniques are percentage and gain test. Research participants was 29 senior high school students. The development product has been judged feasible by experts and through field trials conducted by students. The effectiveness of the product as an instructional media to build computational thinking skills is measured by the gain test. The conclusion is that android-based media is feasible as an instructional media and effective for improving computational thinking skills of high school students.

Keywords: computational thinking, informatic subject, media android-based

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Kehidupan abad ke-21 ditandai dengan perubahan eksponensial yang menyebabkan timbulnya masalah yang semakin kompleks. Kondisi ini mendasari pembelajaran saat ini diarahkan untuk memperlengkapi peserta didik dengan keterampilan memecahkan masalah. Skor tes PISA untuk Indonesia tahun 2018 mengungkapkan bahwa kemampuan penalaran siswa rendah dan kondisi ini mendesak untuk segera diperbaiki. Kemampuan pemecahan masalah dapat dikembangkan dengan meningkatkan keterampilan berpikir komputasional. Konsep

berpikir komputasional di masukkan kedalam mata Pelajaran informatika pada tahun 2021. Media pembelajaran untuk mengembangkan keterampilan berpikir komputasi masih kurang meskipun kebutuhannya sangat mendesak agar keterampilan pemecahan masalah siswa dapat berkembang lebih baik. Penyediaan media pembelajaran berbasis android di era digital dan internet penting sebagai solusi agar kualitas berpikir siswa lebih cepat dikembangkan. Tujuan penelitian memproduksi media pembelajaran berbasis android untuk meningkatkan kemampuan berpikir komputasional. Produk ini dikembangkan dengan metode R dan D dan dengan menggunakan Model ADDIE. Instrumen penelitian adalah angket dan tes hasil belajar. Angket digunakan untuk mengukur kelayakan dari para ahli sedangkan tes hasil belajar untuk mengukur efektivitas produk. Teknik analisis data adalah uji persentase dan gain test. Peserta penelitian adalah 29 siswa sekolah menengah atas. Produk pengembangan telah dinilai layak oleh para ahli dan dilanjutkan dengan uji coba lapangan oleh 29 siswa. Efektivitas produk sebagai media pembelajaran untuk membangun kemampuan berpikir komputasional diukur dengan gain test. Kesimpulannya adalah bahwa media berbasis android layak sebagai media pembelajaran dan efektif meningkatkan keterampilan berpikir komputasional. siswa sekolah menengah atas.

Kata Kunci: berpikir komputasi, informatika, media berbasis android

INTRODUCTION

The 21st century is defined by the increasing complexity of human problems, interconnected situations, and exponential change. Students should be prepared with several 21th century skills. The are four characteristics of 21th century skills, namely add values, abstraction system thinking, experimentation and collaboration (Reich, 1992). The Organization for Economic Co-operation and Development conducted a worldwide PISA survey to assess participating countries' education systems consisting of several skills, namely: science, and reading each 3 years. The Survey PISA in 2018 showed that Indonesia was in 7th position from the bottom in terms of reading, mathematics and science (Schleicher, 2019). This score shows that Indonesian students is in the low performance quadrant with high equity. The score of PISA's test reveals that students' reasoning abilities are low (Lestari dkk., 2020). The urgency to make various efforts to improve students' thinking abilities is undeniable and one of them is by developing students' ability to solve problems. Starting in 2021 PISA includes computational thinking as part of the assessment (Augie & Priatna, 2021). Computational thinking is a term first used by Seymour Papert and popularized by Jeanette Wing (Dagienė & Sentance, 2016). Currently our society lives in a complex computer era, one of approach in solving problems through computer science concepts is computational thinking or CT (Wing, 2008).

Computational thinking in the national curriculum is taught in informatics subjects. Informatics is divided into several elements. Computational thinking is listed as one of the Basic Competencies studied on the topic of Informatics in the Appendix to Permendikbud Number 37, year 2018. Computational thinking, which is to be integrated into the structure of the 2013 curriculum at the elementary, the junior and senior high school levels. Computational thinking plays an important role in making computer applications, this can be used to support problem solving in various academic fields, including humanities, mathematics, and natural sciences. Educators needs provide materials with many platforms of media for high school students develop Computational thinking.

Research findings proven that student learning outcomes and creativity can be improved by improving computational thinking (Kadarwati dkk., 2020). Because learning materials and various instructional media must also be designed, developed and integrated to improve computational thinking skills. In line with the digital and internet era, the provision of instructional media that can be accessed easily has resulted in many Android-based media being developed. Android-based instructional media products for CT learning have received the highest awards in the Bebras Contest which was participated in by 50 countries (Dagienė & Sentance, 2016). The tasks competed in this contest are a way to introduce computer science concepts and at the same time develop computational thinking skills and can be used in various curriculum structures at school, including informatics which are also taught in high school. This product promotes computational thinking and provides useful teaching materials for both teachers and high school students. A literature study of 423 highly reputable journal articles found that Android-based CT instructional media indicates the type of media that can help develop students' computational thinking skill is a programming game (Muflikha dkk., 2023). Games can create learning that is fun, active, creative, and not boring and easy to understand and the application programming game media is widely applied to improve students' computational thinking skills (Muflikha dkk., 2023).

Computational thinking skills are becoming increasingly important considering the current and future era and job vacancies that are closely related to computers and the current world economy (Reich, 1992), (Bower dkk., 2017) Cconsidering that Computational thinking skills have become a basic skill in the 21st century and starting in 2021 the OECD includes Computational thinking skills as part of what is assessed, students need to be equipped with computational thinking skills. In the 2019 national context, senior high schools have included informatics as the main subject, where CT skills are studied in more detail.

The benefits of mastering computational thinking include providing practical strategies for solving problems, developing a more creative thinking pattern, and increasing logical and structures thinking pattern. Senior school students and teachers have been the subject of several previous studies on computational thinking, including by (Nuraisa, 1998), (Kawuri dkk., 2019) looking at the computational thinking skills of high school students, and (Angeli dkk., 2016) who saw the Computational Thinking Curriculum framework.

The Informatics subject become as a compulsory subject at school begin at 2019, and Informatics Teacher's Guidebook from government was published in June 2021. It has just begun. This not happened just in national scale, for example Denmark government conducted survey to collect comprehension information about CT as compulsory education in this country (Caeli & Bundsgaard, 2020). This means a lot of effort has to be made to improve students' CT skills in schools including instructional media that appeal to students. Instructional media to develop computational thinking skills is still lacking even though the need is very urgent so that students' problem-solving skills can develop better. On the other hand, students in the current era of digitalization like digital media and internet-based platforms because of their flexibility and accessibility. The availability of digital instructional media to improve computational thinking skills needs to be strived to build high school students who have increasing problem-solving skills. This R & D research purposed to develop android-based instructional media to improve computational thinking skills. The content of instructional media is designed in the form of games with various problems that must be solved by high school students are expected to contribute to improving human resource development nationally.

METHOD

Research Participant

The research participants of this study was 29 students at the high school from SMA Dharma Wanita 1 Gedangan, Sidoarjo, Grade 10. The students was learning Informatic subject.

Research Design

Instructional media Android-based is named C-Think. C-Think was developed using ADDIE model. ADDIE Model is a systems approach has 5 stages: analyzing, design, development, implementation, and evaluate (Pohan dkk., 2014). The 5 steps of ADDIE Model are described at Figure 1.

[Figure 1 about here.]

Analyzing Stage

The main purpose at analysis stage is to conduct an analysis need, such as literature studies, student characteristics, and curriculum analysis (instructional goals and potential school environment). Many previous researches have proved that there have been an increase academic performance, especially motivation to learn and students' cognitive learning outcomes, can assisted by the use of instructional media that is interesting and supports learning. System requirements in making games related to C-Think includes: 1) Software requirements: Website 2 APK Builder, iSpring Suite 9 and Microsoft PowerPoint 2016; and 2) Hardware requirements: Intel Core i5 processor, Processor Speed 2.7 GHz, Memory 8 GB and Intel Iris Graphics 6100 1536 MB graphics.

Study of literature showed that the smartphone is widely used with Android operating system. Counter Global Stats 2015 places Android in first place in using the smartphone operating system and tablets with more than 50% of users total smartphone users as of April 2015. Android smartphones are also widely used in supporting learning at school. A survey was carried out with observations and interviews at SMA Dharma Wanita 1 Gedangan. Computational thinking concepts was teach mostly using expository strategy and drills.

Design Stage

Developer was classifying the material regarding to competencies or material presented in the game, then proceeding to compiling a material framework, compiling a storyline, compiling a flow chart, compiling a storyboard. Interface was designed consist of 5 parts such as opening design, home design, game page design, game end page design and information page design.

Develop Stage

This stage included: (1) Android-based C-Think interface and form design (2) creation of digital material by referring to material questions in BERBRAS SMA 2016 (Indonesia, 2016), BEBRAS SMA 2017 (Indonesia, 2017), BERBRAS Competition 2020 (Bebras, 2020), (3) preparing storyboards, (4) mapping process, data using and evening (implementing storyboards in Ispring Suite 9) and (5) preparing a guide for using Android-based C-Think.

After the Android-based C-Think developed, several experts were asked to reviewer the product. The developer made revises until the quality of product fulfill according to experts' suggestions. The experts are instructional media experts, Subject-Matter Experts (content experts), and instructional design experts.

Implementation Stage

Products that have been improved according to advice from experts are then tried out on students. Product had been improved and revised according to experts' advices. Tried out on students and implemented sequentially namely: One-to-One evaluation (followed by eight students), small group evaluation and trial out or classroom evaluation (following by all student in the class). A pretest and posttest were carried out at the last one.

Evaluation Stage

The evaluation carried out at each of the four stages is called formative evaluation, which aims to produce prototype. Evaluation in this last stage is a summative evaluation. Developer disseminates prototype products to schools widely and variedly to obtain product validity and effectiveness. The developer did not carry out a summative evaluation because it needed separate design and activities on a fairly large scale and had to be carried out outside of this R and D research.

Data Collection Technique

Data was collected for two purposes, namely obtaining feasibility and effectiveness. Data were collected by questionnaires and learning outcomes tests. The questionnaires contain several questions or statements which answer by choose in one of scores from "poor" (score 1) to "excellent" (score 4). The accumulating scores from experts then converting into percentages (see Table 1). The formula according to (Sugiyono, 2014) as follow:

$$\text{Persentase kelayakan} = \frac{\text{skor yang diperoleh}}{\text{skor yang diharapkan}} \times 100\%$$

Experts' assessments are analyzed using the categories described in Table 1.

[Table 1 about here.]

The results of the data analysis are then interpreted and concluded according to feasibility criteria as in the Table 2.

[Table 2 about here.]

Product effectiveness measure with gain-test. Learning outcomes consist pre-test and post-test. Data was analyzed using the gain-test The gain-test data analysis technique is to calculate the gain value (g),

$$g = \frac{skorposttest - skorpretest}{skormaksimum - skorpretest}$$

Hake (2012: 1)

Pretest (before students use product C-Think) and posttest (after students used product C-Think) were conducted to find out the difference learning outcome of usage (or not usage) of instructional media C-Think.

FINDINGS AND DISCUSSION

The development of C-Think instructional media followed ADDIE Model. ADDIE is a systems approach, all design, development, implementation and evaluation activities need to be coordinated and to analyze how its components interact with each other (Pohan dkk., 2014). To create C-Think Android learning resources that follow a model with stages such as: Analyzing, Design, Develop and Implementation.

Product Develop

The product developed can be operated on Android devices. The menu contained such as (1) opening, (2) home, (3) materials, (4) videos, and (5) game. The appearance of the main menu can be seen in Figure 2. In the opening menu there is the UNIPA logo and C-Think logo which are used as start buttons to the main menu of the instructional media application.

[Figure 2 about here.]

Figure 3 is the home interface design. Home is the main display of Android-based interactive instructional media. On the home page there is a title, menu: material; videos; exercise; and there are instructions for using instructional media.

Menu Content CT was put at the second main page and divided into several learning objectives pages. Sub-topics contained at several next pages and Home menu was put on each page, making students easier to return to the home page (figure 3).

[Figure 3 about here.]

[Figure 4 about here.]

For each learning objective, a link is provided containing learning material. The learning material is in the form of a summary of the material. On each page, audio facilities are provided which make it easy for students to listen to audio recordings of the material without having to read. This feature can be used by activating the sound icon in the bottom right corner. Apart from that, back and next navigation buttons are provided to make it easier to run the application (figure 5).

[Figure 5 about here.]

A video menu is provided to assist students in studying this material. In this video menu, four videos are provided according to the learning objectives, these four videos include computational thinking, sorting algorithms, searching algorithms and problem discussions. The following displays the menu interface design for videos.

[Figure 6 about here.]

On each video menu page there is a home icon and a home button, both of which make it easier for students to run this application.

The game menu contains computational thinking questions taken from BERBRAS. This question consists of two levels, namely the Narendra level (easy) and the Pramudya level (difficult). Before working on these questions, there are instructions for working on these questions. The following is a display of the game instruction page interface.

[Figure 7 about here.]

After clicking the start button, the display will change as shown in the interface in Figure 7. There are two levels of play in the game, namely the Narendra level (easy) and the Pramudya level (difficult).

[Figure 8 about here.]

Narendra's practice questions consist of 12 multiple choice questions with a processing time of 45 minutes and at the pramudya level there are 15 multiple choice questions in 45 minutes. At the narendra and pramudya levels there are types of questions in accordance with the four pillars of computational thinking including decomposition, generalization (abstraction), pattern recognition and algorithms (algorithm design or design). The following is the initial display of the Narendra and pramudya menu:

[Figure 9 about here.]

Student enters name and email starting the game, then click the start quiz button and the interface will change to the following Figure 10.

On each question page at the Narendra and Pramudya levels, a feature (voice) is provided. This feature is provided if the user is reluctant to read the question, the user can click on this feature to listen to the voice recording containing the questions listed on the page.

[Figure 10 about here.]

Each question contained in the game level has the same score with a processing time of 3 minutes. Students are declared successful if they have a score of 80, while they are deemed to have failed if they have a score below 80 and display like at Figure 11 and 12.

[Figure 11 about here.]

[Figure 12 about here.]

After completion, students can repeat the evaluation questions by pressing the "Retry Quiz" button if they feel that the score obtained is not optimal.

[Figure 13 about here.]

Products that have been developed are then assessed by experts, consisting of subject matter-expert (SME), instructional media and instructional design (see Table 3, 4 and 5). The results of SME are display at Table 3.

[Table 3 about here.]

Table 3 displayed that the Android-based C-Think product is very feasible because it received a score of 92%. This is very important because, the score shows that the information designed in instructional media has been accurate and reliable so that students avoid misunderstandings (Mawaddah dkk., 2019).

C-Think products were also carried out by instructional media expert and the result displayed at Table 4. The Android-based C-Think product is very feasible because it gets a score of 89%. Based on the feasibility scores obtained, it is proven that C-Think as an instructional media that has been developed has fulfilled the rules and principles of instructional media, because (Efrialda & Subiantoro, 2022) media expert validation is the process of evaluating a media product to determine its suitability as an instructional media.

[Table 4 about here.]

Table 5 displayed review result from Instructional design expert. The score was 91,4% which means the product was very feasible. In addition, experts also provide additional suggestions that are important to optimize the validity of product development.

[Table 5 about here.]

After the product is declared feasible based on the statements of the experts, it is tested on users or students at SMA Dharma Wanita 1 Gedangan (Efrialda & Subiantoro, 2022). Practicality testing was carried out which includes (1) small group trials with 6 students, and (2) large group trials with 20 students. The results of the small group trial displayed at Table 6, as follows:

[Table 6 about here.]

The score from the small group tests was 83, 67% which means that C-Think product is very practical. Meanwhile, for field trials, the results displayed at Table 7.

[Table 7 about here.]

In the field test the C-Think product was very practical because it got a score of 83.1%. Based on the results of feasibility tests both in small group tests and tests. The large group that got the results was categorized into very practical ones. The level of practicality of a media being developed refers to the ease of use by users, both students and educators, so students can be learning were more meaningful, interesting, enjoyable and stimulates creativity Practicality of a instructional media must also pay attention to several aspects such as, (1) aspects of the format available, the time to use the media during learning and the costs that must be incurred to use the media. (2) suitability of the content or format of the media to the character, learning style, development and experience of students, and (3) suitability of the media to the learning carried out by educators and being able to facilitate participants.

Product Effectiveness

There were 29 students who participated in the product development trial. The effectiveness of product development was measured by comparing learning outcomes before and after students learn using the media. The pretest score was 38.45 and the posttest was 61.14. The data is analyzed with a gain test and its value is -14.162 as shown in Figure 14. The value means that there were significant differences learning outcomes in computational thinking skills before and after students solve problems designed on the media that has been developed. This means that this media is effective as an instructional media to improve computational thinking skills.

[Figure 14 about here.]

CONCLUSIONS

This Android-based media was developed using the ADDIE model which was tested with a series of feasibility and practicality tests. The conclusion were the product

feasible as instructional media and effective to improve students Computational Thinking skill of high school students. Researchers are advised to conduct assessments of students with a larger scale and different student characteristics.

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LIST OF FIGURE

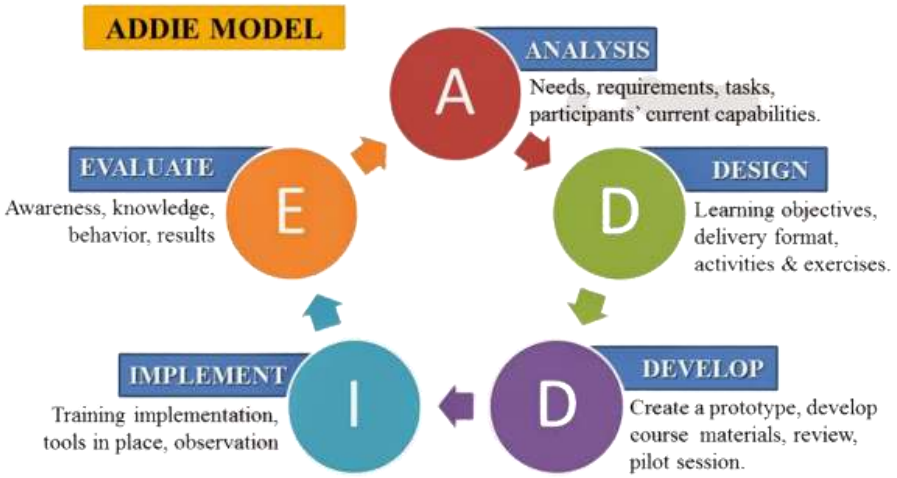

Figure 1 / ADDIE Model *(https://grafispaten.files.wordpress.com/2016/01/c3a33-desain.jpg.)*

Figure 2 / First Page

Figure 3 / Main Menu

Figure 4 / Display of the Material Interface and Learning Sub-Goal Interface (Sub Material)

Figure 5 / Material C-Think

Figure 6 / Menu Video

Figure 7 / Menu Game

Figure 8 / Game Menu

Figure 9 / Login Menu

Figure 10 / Question Page of Narendra and Pramudya Level

Figure 11 / Example Score if Passed 80

Figure 12 / Example Score if Failed

Figure 13 / End Page

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	PRETEST - POSTTEST	-22.690	8.628	1.602	-25.971	-19.408	-14.162	28	.000

Figure 14 /Pair Sample Test

LIST OF TABLE

Table 1 / Category of Validity

Percentage (%)	Category of Validity	Decision
< 20	No Valid	Rejection
21-40	Less valid	Revision
41-60	Valid enough	Revision
61-80	Valid	Less revision
81-100	Valid	No need revision

Resource: (Ariani, 2020) and (Riyadi dkk., 2019)

Table 2 / Feasibility Criteria

Value of N-Gain	Category
g > 0,7	High
0,3 ≤ g ≤ 0,7	Average
g < 0,3	Low

Table 3 / The Results of SME Review

No	Component	Maximal Score	Score obtained
1	The level of relevance of teaching materials to the curriculum	5	4
2	Accuracy of unit titles with descriptions of material in each unit	5	5
3	Clarity of introduction to each theme	5	5
4	Clarity of content framework (epitome)	5	5
5	Suitability of indicators and learning outcomes\	5	4
6	Conformity of indicators to descriptions	5	4
7	Compatibility between learning outcomes, indicators and material description	5	5
8	Clarity of description	5	4
9	Suitability of the examples presented to the learning material	5	4
10	Clarity of solving sample questions between material descriptions	5	4
11	Clarity of summary content	5	5
12	Competency test conformity with learning outcomes	5	5
13	Attractiveness of components in teaching materials	5	5
14	The appeal of learning content	5	5
15	Interesting organization of teaching materials using the Dick and Carrey model	5	5
	Total	75	69
	Eligibility Percentage (%)		**92**
	Eligibility Category		**Very Feasible**

Table 4 / The Results of Instructional Media Review

No	Component	Max Score	Score obtained
1	The accuracy of illustrations used in instructional media	5	4
2	Compatibility between the material and the media used	5	5
3	Page conformity	5	4
4	Font size accuracy	5	4
5	Accuracy of image placement	5	5
6	Text quality	5	4
7	Organizing the design of learning messages	5	5
	Total	35	31
	Eligibility Percentage (%)	**89**	
	Eligibility Category	**Very Feasible**	

Table 5 / The Results of Instructional Design Review

No	Component	Maximal Score	Score obtained
1	The accuracy of the illustrations used in the *game*	5	4
2	Compatibility between the material and the media used	5	5
3	Navigation in *game operation*	5	5
4	Font size accuracy	5	4
5	Accuracy of illustrations placement	5	5
6	Text quality	5	5
7	Organizing the design of learning messages	5	4
	Total	35	32
	Eligibility Percentage (%)	**91,4**	
	Eligibility Category	**Very Feasible**	

Table 6 / The Results of Small Group Evaluation

No	Aspects	Indicator	Score obtained	Max Score
1	Effective	1. Instructional media can be used to explain the material	25	30
		2. Quizzes can be used to assist in the evaluation process	24	30
2	Interactive	3. All buttons from the instructional media can be used properly	25	30
		4. The scale of the three-dimensional model can be adjusted	21	30
		5. The letters displayed are easy to read and always face the screen	21	30
		6. The displayed value corresponds to the calculation.	27	30
3	Efficient	7. Instructional media is easy to use anywhere	30	30
		8. Instructional media is easy to carry	30	30
4	Creative	9. The presentation of questions in the form of quizzes attracts students to complete them.	24	30
		10. Instructional media can help students to be active in the learning process	24	30
Total			**251**	**300**
Eligibility Percentage			**83, 67**	
Eligibility Category			**Very Feasible**	

Table 7 / The Results of Field Trials Evaluation

No	Aspects	Indicator	Score obtained	Max Score
1	Effective	1. Instructional media can be used to explain the material	85	100
		2. Quizzes can be used to assist in the evaluation process	80	100
2	Interactive	3. All buttons from instructional media can be used properly	83	100
		4. The scale of the three-dimensional model can be adjusted	69	100
		5. The letters displayed are easy to read and always face the screen	67	100
		6. The displayed value corresponds to the calculation.	87	100
3	Efficient	7. Instructional media is easy to use anywhere	100	100
		8. Instructional media is easy to carry	100	100
4	Creative	9. The presentation of questions in the form of quizzes attracts students to solve them.	80	100
		10. Instructional media can help students to be active in the learning process	80	100
Total			**831**	**1000**
Eligibility Percentage			**83,1**	
Eligibility Category			**Very feasible**	