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Development of STEM-Based Learning Videos on *Escherichia coli* Bacteria

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ABSTRACT
The purpose of this study was to determine the design and feasibility of STEM-based learning videos with the topic of identifying Escherichia coli bacteria in well water. This type of research is research & development with a 4D development model. but this research focuses on 3 stages, namely define, design, and development. The research subjects were students of the 6th semester of Biology Education Study Program with a total of 7-10 students as respondents. The validation test uses 3 validators who validate the material and media. The data collection instrument used a validation questionnaire and a student response questionnaire. The results of the data obtained indicate that the STEM-based learning video product related to Escherichia coli bacteria in well water is in the "Eligible" category with a percentage of material elements of 72% and media elements of 78%. For student responses, it shows the enthusiasm of students to use this product for learning media with a percentage of 80.5%. This product is expected to be used in learning activities to see the effectiveness of the product on student learning outcomes. This learning video product can be used as a variety of learning resources.

Keywords: *Tutorial Video; STEM; Escherichia Coli Bacteria.*

INTRODUCTION
The development of information and communication technology (ICT) has brought various influences on various areas of life, one of which is the field of education. In line with the technological advances, there are reforms in the field of education such as curriculum, learning models, and tools or media in learning activities (Sulaikho, 2021). The presence of ICT in the world of education has been integrated in all subjects, namely by utilizing ICT in the teaching and learning process activities. The utilization of ICT in teaching and learning process activities is one form of application of the Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 65 of 2013 concerning the standard of primary and secondary education process in point 13, namely the principle of learning where the use of ICT to improve the efficiency and effectiveness of learning (Suhir & Duri, 2008).

21st century education is characterized by the rapid development of technology that can improve the quality of education itself. There are four competencies required by students in the 21st century that are integrated with the curriculum, namely Critical thinking and Problem Solving, Communication, Collaboration, Creativity and Innovation, or 4C (Redhana, 2019). In the competence of the 21st century students have learning skills, innovate, skills in using technology and information media and can work and survive by using life skills (Firdaus & Hamdu, 2020).

In line with 21st century education, the use of science especially in the fields of science, technology, engineering and mathematics plays an important role in the world of education. The four fields are known as STEM, namely science, technology, engineering and mathematics (Irawati et al, 2020). With STEM learning, students do not get bored and provide students with an engaging learning experience, support students' skills and knowledge and can improve the quality and skills of teachers to plan STEM learning in classroom learning (Firdaus & Hamdu, 2020). Stem learning can help students to collect, analyze, solve problems and be able to understand the relationship between one problem and another (Nessa et al., 2017).

The goal of STEM education for all students is to apply and practice the basic content of STEM in the situations they face/find in life, becoming STEM literacy' (Bybee, 2013). STEM literacy refers to: a) An individual's knowledge, attitudes, and skills to identify real-life questions and problems, explain a natural and design world, and describe facts-based conclusions on STEM issues, b) An individual's understanding of the karakeristic nature of STEM disciplines as a form of human knowledge, inquiry and design , c) An individual's sensitivity to how STEM shapes the material, intellectual and cultural of our environment, and d) An individual's desire to be tied to STEM issues and tied to the ideas of science, technology, engineering, and mathematics as a constructive, caring and reflective citizen.

STEM provides more benefits to the learning process. (Sukmana, 2017) states that STEM provides benefits such as: a) Having real-world issues and problems in the hearts of learners. Hereby expected to foster empathy and reduce fighting, b) Tying learners to guided inquiry and open closed exploration, c) Actively integrating engineering design processes, d) Helping students see the relationship between science and mathematics through content integration, e) Expecting and facilitating collaboration between learners, discourse and sensitivity, f) Inviting risk by starting a learning environment that seeks more than one solution over each mass ah, and g) Understand that failure is part of the process and appreciate it.

Along with the development of the times and technological advances, the world of education must also follow the development of such technology. Teachers are the key in improving the quality of education and teachers must be able to follow and take advantage of the development of the technological age (Achmad & Pea, 2020). The development of science and technology is needed a business that can facilitate access to the development of these sciences (Wiyono et al., 2012).

Video is one of the technological advances that has influenced human progress, especially in the world of education. Video as one of the technological advances has given a lot of positive influence and progress for humans today (Firdaus & Hamdu, 2020). One of the media information and communication technology that is able to reach and most popular among the public is video media. Video is also an electronic medium that is able to combine audio and visual technology together to produce a dynamic and interesting impression. With these two elements, students are expected to be able to receive, understand, and remember the message of learning. Audio visual media has the function (1) clarifying the presentation of the message so as not to be too verbalistic, (2) overcome the limitations of space, time and sensory power, (3) the proper and varied use of educational media can overcome the passive nature of students (Yuanta, 2019).

There are many advantages of video when used as a learning medium among others, video is a suitable medium for various learning media, such as classes, small groups, even one student alone. Videos with a duration of only a few minutes can provide more flexibility for teachers and can direct learning directly to the needs of students (Busyaeri et al., 2016). In addition, video can also be used for almost any topic, type of learning, and every realm of both cognitive, affective and psychomotor.

STEM-based learning videos have a good impact on the learning process. The results of several studies showed that the use of learning video media showed that the students managed to obtain scores above the set minimum completion criteria (Yuanta, 2019). In addition, the use of STEM-based mobile learning is expected to provide concrete and concrete examples of STEM learning in the classroom supported by enrichment modules, learning implementation plans, media, student worksheets, test questions and performance assessments (Firdaus & Hamdu, 2020).

Based on the background, the researchers intend to conduct a study on STEM-based learning videos to improve students' ability to identify Escherichia coli bacteria.Stem approaches are chosen so that learning media can be applied properly. The purpose of this study is to know the design and feasibility of STEM-based learning videos with the topic of identification of Escherichia coli bacteria in well water so that in the future it can be used as a supporting medium in the teaching and learning process.

METHOD

This type of research is a research method used to produce certain products, and test the effectiveness of those products (Sugiyono, 2018). The development model used in this study follows the steps of the Four-D (4-D) development model developed by Thiagarajan, Doroty S.Semmel, and Melvyn I.Semmel (Suryawan & Permana, 2020). The following development model designs are used as follows:

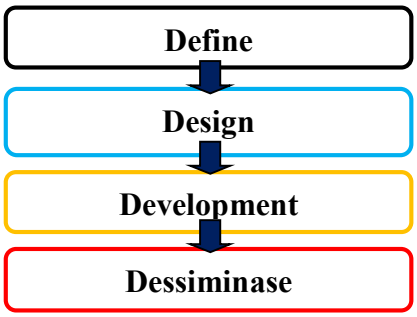

Figure 1. The Flow Of Thiagarajan Et Al Development Model (As'ari, 2019)

The subject of this study trial was a 6th semester biology student of KH. A. Wahab Hasbullah University even semester 2020-2021. Limited trial subjects numbered 7 biology students semester 6. This type of data from this study is quantitative data and qualitative data because this research was conducted with research "Research and Development"(R&D). Quantitative data is the validation of media experts and material experts (poll results). Qualitative data is data on suggestions, opinions or responses from validators and also student responses. The instruments used in this study are media validation sheets, material validation sheets, and student response questionnaires.

The questionnaire used in this quantitative data analysis uses a likert scale. The assessment of the likert scale category described by (Riduwan, 2019) can be seen in Table 1.

Table 1. Likert Scale Category Assessment Guidelines

Media and Material Validation Assessment	Student Response Assessment	Score
Very worthy	Very Interesting	5
Worth	Interesting	4
Decent enough	Interesting enough	3
Less worthy	Less attractive	2
Not Good	Very Unattractive	1

The validation assessment data of media experts, material experts, and student responses collected is analyzed in sum, compared to the expected amount so that a percentage is obtained (Riduwan, 2019), or can be written with the following formula:

Eligibility Percentage (%) = X (validator expert score) / Xi (max score) x 100% ….. (1)

Eligibility Percentage (%) =∑X(total score of students) / ∑Xi(total max score) x 100%....(2)

The collected data is analyzed with quantitative descriptive analysis techniques used in the distribution of scores and percentages against a predetermined category of assessment scales. After presentation in percentage form, the next step is to descript and draw conclusions about each indicator. Conformity of aspects in the development of learning video media can use Table 2.

Table 2. Percentage Scale Criteria

Achievement percentage (%)	Media and material validation assessment criteria	Student response assessment criteria
81-100	Very worthy	Very Interesting
61-80	Worth	Interesting
41-60	Decent enough	Interesting enough
21-40	Less worthy	Less attractive
0-21	Not Good	Very Unattractive

(Riduwan, 2013)

RESULT AND DISCUSSION

Result

The test results of the development product are based on the development steps used i.e. 4D.but in this study only focus on 3D namely Define, Design, and Development.For the Disseminase stage can not be implemented because it requires more time and energy.Here are the results of the research data:

- *Define*

This stage shows the process of preparing researchers to conduct their research. Researchers conducted análisis needs first by examining some of the problems and potentials that are around them.Researchers conducted preliminary studies by reviewing some relevant research results.Then the researchers conducted a survey of the location that was used as material for the development of learning videos.

Based on the results of the survey, researchers found that the average resident in Kedungjati village still uses the well as a source of water that they use for household purposes such as cooking, bathing, washing and other purposes. From some wells in Kedungjati Village, the average is close to bathrooms and household waste (sewer water). Where it can be one of the factors contaminated with well water by bacteria.Therefore, researchers are interested in testing the quality, feasibility of water sources used by local Kedungjati villagers.

Sampling starts on April 12, 2020, from 6:30 a.m. to 7:45 a.m., from two different points. The first point, is interrupted by people's houses, well walls cemented, close to bathrooms and household waste (sewers). The second point, being in an open space, the well wall is also cemented, close to the chicken coop and household waste (sewer water).The tools needed at the time of sampling are glass bottles, hand hanskun, coffee paper, ropes, candles and matches.

- *Design*

Based on data obtained from the define stage obtained data that the right media and in accordance with the development of the times and technological advances is a learning video with STEM-based. The learning video presents brief material on Escherichia coli bacteria, the sampling process and the practice process of testing the quality of Escherichia coli in well water, as well as STEM analysis.

The sampling process was conducted in Kedungjati Kabuh Jombang Village which consists of 2 samples.As for practicum quality test Escherichia coli in well water is conducted in the Laboratory of Balai Besar Perbenihan dan Perlindungan Perkebunan (BBPPTP) Mojoagung Jombang. During video shooting in March 2021 it was done using a 1300D DSLR camera and several other supporting devices such as tripods and microphones.

The material description and STEM analysis section uses a PowerPoint (PPT) application that is converted into a video. Dubbing is done after the merge process of all videos is complete. The editing process (merging all videos and dubbing results) uses the Adobe Premiere Pro application.The finished video is then stored as a CD, labeled with a place / CD box that is given a cover in accordance with the material described on the video.

Here is a STEM-based learning video design with the topic of identifying Escherichia coli bacteria in well water.

Figure 2. STEM-Based Learning Video Initial Display Design

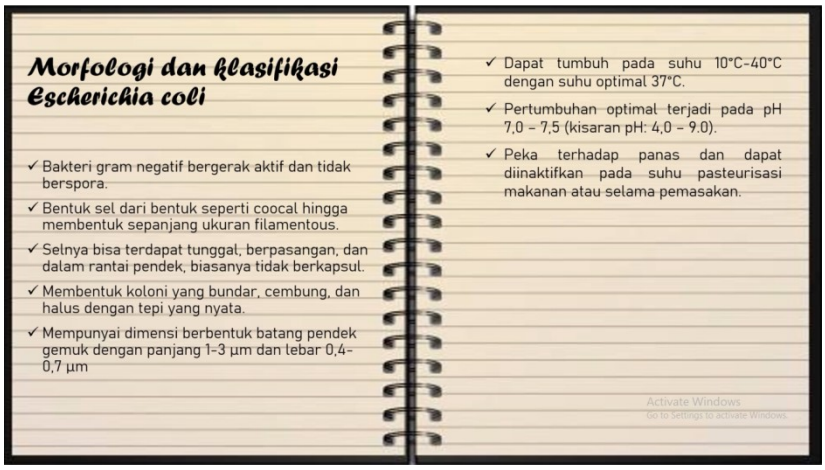

Figure 3. Material Display Design on STEM-Based Learning Video

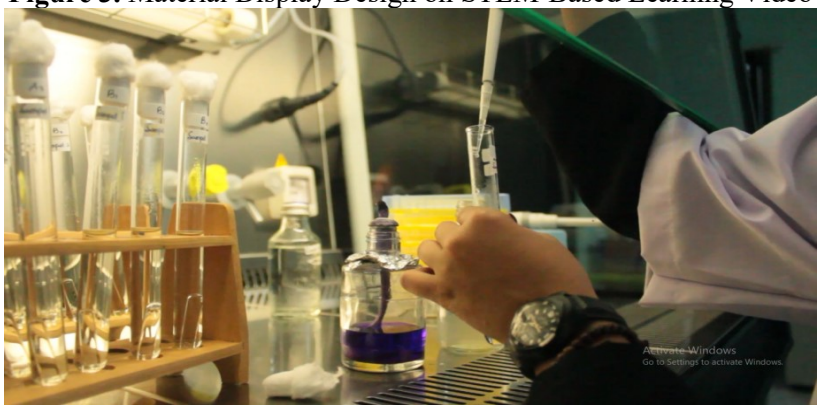

Figure 4. Design Display of STEM-Based Learning Video Footage related to Well Water Quality Test Activities

- *Development*

In this third stage, the learning videos that have been developed will be validated by experts to determine the feasibility of the video that has been created. Experts will assess and provide useful comments and suggestions to make the video even better. Validation is performed by media experts and material experts, as well as filling out response questionnaires on users. The recapitulation data can be seen in Table 3 for material validation results and Table 4 for media validation results.

Table 3. Material Validation Result Data

No	Rating Details	Score		Information
		Average	%	
1.	The truth of the practical concept of well water quality testing	4,00	80	Feasible
2.	The words and terms used are consistent	3,33	66	Feasible
3.	Figure and animation suitability with the material	3,00	60	Decent Enough
4.	The scope of the material is related to the sub-material discussed	3,67	73	Feasible
5.	The truth of the content submitted	3,67	73	Feasible
6.	Submission of material logically and systematically	4,00	80	Feasible
7.	STEM analysis is in accordance with the scope of the material	3,67	73	Feasible
	Average	**3,62**	**72**	**Feasible**

Table 4. Media Validation Result Data

No	Rating Details	Score		Information
		Average	%	
I	**Language**			
1.	Use of EYD-compliant languages	3,33	66	Feasible
2.	Use of language that does not give rise to double interpretation	3,33	66	Feasible
3.	Easy-to-understand use of language	4,00	80	Feasible
II	**Video Quality**			
1.	Figure Focus	4,00	80	Feasible
2.	Font size	4,00	80	Feasible
3.	Font size Voice actor quality /dubbing	3,67	73	Feasible
4.	Volume	4,00	80	Feasible
5.	Musical instruments	4,00	80	Feasible
III	**Serving**			
1.	Interactive video display	3,33	66	Feasible
2.	Interesting practicum presentation	4,33	86	Very Worth
3.	Practical presentation is easy to follow	4,00	80	Feasible
4.	Help learn independently	4,33	86	Very Worth
5.	Ease of optimizing videos	4,67	93	Very Worth
	Average	**3,92**	**78**	**Feasible**

In addition to the validation results, researchers also conducted product trials with users (students) to see responses to stem-based learning video media. The recapitulation results are presented in Table 5.

Table 5. User Test Result Data (Student Response)

No	Rating Details	Score			Information
		∑X	∑Xi	%	
1.	The look of this learning media is interesting so as to make it more vibrant	31	88	31	Very Interesting
2.	The material presented in this medium is easy to understand	29	82	29	Very Interesting
3.	Figures and animations presented according to the material	30	85	30	Very Interesting
4.	Types of text used in easy-to-read learning videos	33	94	33	Very Interesting
5.	The language used in this medium is simple and easy to understand	29	82	29	Very Interesting
6.	The sound in this learning video is clearly heard	29	82	29	Very Interesting
7.	This learning medium is easy to operate	30	85	30	Very Interesting
8.	This learning medium makes it easy to learn independently	16	45	16	Quite Interesting
9.	The figures in the learning video can be clearly seen	29	82	29	Very Interesting
10.	This learning video media pioneers understanding STEM in Escherichia coli material	28	80	28	Interesting
	Average	**28,4**	**80,5**	**28,4**	**Interesting**

Based on the data above, STEM-based learning videos on Escherichia coli bacterial material have been revised in their development. In addition to quantitative data, there is also qualitative data from product feasibility tests (validation) and student response tests in the form of suggestions and comments. In general, this learning video needs to be revised on several things, among others: a) the bacterial image should be the original image instead of the animation, b) the writing of the scientific name must be correct, c) the STEM component needs to be examined more deeply, d) the learning objectives need to be

listed, e) the reference of each image should exist, f) it is necessary to add a description of the benefits and dangers of Escherichia coli, and g) in practicum presented the name of the tool and material used.Therefore, STEM-based learning videos on Escherichia coli materials are suitable for use in learning and help to motivate in learning but there needs to be improvements according to the validator's advice and student response.

Discussion

STEM-based learning videos on Escherichia coli material need to be examined more deeply regarding video characteristics, product suitability with development goals and the advantages and disadvantages of such products. The characteristics of this learning video are STEM-based which is associated with the material used i.e. Escherichia coli material. In this video, there are 3 elements, namely a) Escherichia coli material, b) well water quality test, and c) STEM analysis. This STEM analysis refers to the serving of Escherichia coli material and the practicum activities of well water quality testing.

This STEM-based learning video on Escherichia coli material is indeed a source of information. This video was developed to support students in understanding Escherichia coli material. In addition, this video is also a reference for the general public regarding well water quality testing activities and its relation to Escherichia coli bacteria. This can be seen in the video footage in Figure 5.

Figure 5. Video Footage of Well Water Quality Test

Stem-based learning videos on Escherichia coli bacterial material have advantages such as: a) varied learning resources for students, b) overcome the limitations of space and time in learning, and c) can be integrated into online learning. In addition to the advantages, this video also has a drawback that educators take a long time to compose material in the form of video. This requires educators to be more skilled and have competence in utilizing the science and technology that is around. Educators also need to have supporting facilities and infrastructure for the development of learning videos.

CONCLUSION

Based on the results of data obtained through the stages of define development, design, and development that STEM-based learning videos on escherichia coli bacterial material in the category "Feasible" with a percentage of 72% in the material element and 78% in the media element. The student response is very enthusiastic in using this learning video. Therefore, this learning video can be used in the learning process but needs to be improved according to the suggestions and comments of validators and students.

STEM-based learning videos on Escherichia coli bacterial material need to be extensively tested or continue the development phase of disseminase. This is to know the effectiveness of this learning video product to the learning process. This trial needs to be done in the next study. In addition, this learning video can be implemented with a variety of bacterial materials. To support this, it is necessary to prepare supporting facilities for the product development process in order for the product to be more qualified.

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