

# Project based learning STEM to enhance secondary school students' comprehension on projectile motion

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**Keywords— Corona Virus Disease 2019,  
pandemic, STEM.**

**Abstract—** At the beginning of 2020, the Covid-19 pandemic has influenced learning activity where students and teachers have to adapt from face-to-face learning to online learning. This study aims to overcome the issue by developing a learning media with Project-based learning STEM on projectile motion. The media which accommodated the catapult project was developed for secondary schools on google sites. In this research, the media was developed by conducting the Research and Development (RnD) method with the ADDIE model, consisting of five steps: analyze, design, develop, implement, and evaluate. Furthermore, the media was validated by experts and then implemented to the students. Finally, the validation and implementation results were analyzed with four points of the Likert scale. The validation results showed that the average score of the material aspect was 3.8. Meanwhile, the media aspect was 3.3. After the revision, the media was implemented to the students. The average of implementation cores showed that the material aspect was 3.6, the media aspect was 3.6, and the benefit aspect was 3.5. Both validation and implementation results showed that the media was excellent. Therefore, the project-based learning STEM with a catapult project can be applied as a supplemented media for the projectile motion learning process and applied in online learning during the covid-19 pandemic.

## I. INTRODUCTION

The Corona Virus Disease 2019 (Covid-19) has influenced the world since the beginning of 2020. Later on, the World Health Organization (WHO) announced that Covid-19 was a pandemic [1]. This situation does globally impact the economy and the educational sector[2].Consequently, the students cannot study at school to avoid the virus spreading. However, on the other hand, the learning activities must keep going. Therefore, the teacher needs to convert the learning activities[3]from face-to-face learning to online learning[4].In addition, appropriate learning

media and model is also needed to support the online learning process during the pandemic Covid-19.

In the 21st century, digital learning media such as websites is more often applied[5]. Therefore, students can study and comprehend the learning material anytime and anywhere through the website. Along with the media, the learning model is also developed rapidly today. For example, the combination of Science, Technology, Engineering, and Mathematics as STEM learning models to enhance students' skills[6], and replace "teacher center" learning with project-based learning[7][8]. Project-based learning applies projects as a learning process[9]and set

"students center" in the learning process [10]. Therefore, students can complete the task independently with design, problem-solving, and decision-making skills [11].

Several studies combined project-based learning with STEM to obtain a better result in the learning activity. For example, a project-based learning STEM module was developed to support students in accomplishing a biology project[12]. Besides module, project-based learning STEM websites and video conferences were also conducted to enhance organizational and communication skills [13][14]. In another research, project-based learning STEM was also conducted to enhance the students' comprehension of the engineering design process[15].

Based on those previous research, we combined project based-learning and STEM to enhance student comprehension of physics material, especially the projectile motion, during the online learning. The combination of project-based learning and STEM at Indonesian secondary school has not been applied yet. It was shown by physics teachers' interviews at the 107 Jakarta secondary school, where the learning process was still "teacher-centered." Besides, the questionnaire result of 9th-grade students at 107 Jakarta secondary schools showed that the student comprehension on four projectile motion questions was 64%, 58%, 64%, and 70%. These results indicated that students' fundamental knowledge and comprehension were low. Therefore, this study developed project-based learning STEM media to enhance students' comprehension of projectile motion material. In addition, project-based learning STEM which has five steps: 1) Reflection; 2) Research; 3) Discovery; 4) Applications; 5) Communication[16]is in line with the 2013 curriculum in Indonesia[17].

**II. METHODOLOGY**

This study conducted the Research and Development (RnD) method with the ADDIE model, consisting of 5 stages: analyze, design, develop, implement, and evaluate. The cycle of the ADDIE model is shown in figure 1 [18].

The first stage was analyzed. Here, an assessment need and literature review were conducted to identify the teachers' and students' problems in the learning process during the pandemic. The need analysis was obtained from teachers' interviews and students' questionnaires. Meanwhile, the literature review was attained from several references. Then, the second stage was designed. After identifying the problems, the learning media was designed by setting the learning objectives, stages, materials, assignments, guidance, and validation instruments. Next, the stage was developed. Here, the learning media was built on google sites. The fourth stage is implementation.

In this stage, the learning media was validated by experts and then implemented to the students in the learning process.

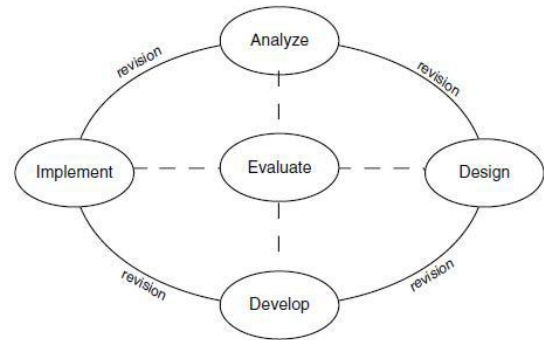


Fig.1. The cycle of the ADDIE model

The validators were from the Physics Education and Physics department at Universitas Negeri Jakarta. Finally, the media was evaluated and improved in the last stage based on the validation and implementation results. Here, the results were analyzed by four points of the Likert Scale. The average scores were obtained from the following formula.

$$\bar{x} = \frac{\sum x}{n} \tag{1}$$

where,  $\bar{x}$  is the average score,  $\sum x$  is the total scores and  $n$  is the number of questions. The product quality could be qualified based on the following classification [19].

Table 1. The score range classification

No	Score Range	Criteria
1	$3.25 < \bar{x} \leq 4.0$	Excellent
2	$2.5 < \bar{x} \leq 3.25$	Good
3	$1.75 < \bar{x} \leq 2.5$	Fair
4	$1.0 < \bar{x} \leq 1.75$	Poor

Table 1 showed the score range from 1.0 to 4.0. Thus, the learning media could be proceeded to the implementation stage, once the  $\bar{x}$  was larger than 2.5. Meanwhile, if the  $\bar{x}$  was lower than 2.5, then the media should be revised and revalidated.

**III. RESULTS AND DISCUSSION**

Project-based learning STEM media on the projectile motion for secondary schools has been developed. The developed media was a website built on googles sites. Here, the media title was a catapult project which can be accessed on the following link

<https://sites.google.com/view/media-proyek-ketapel>.

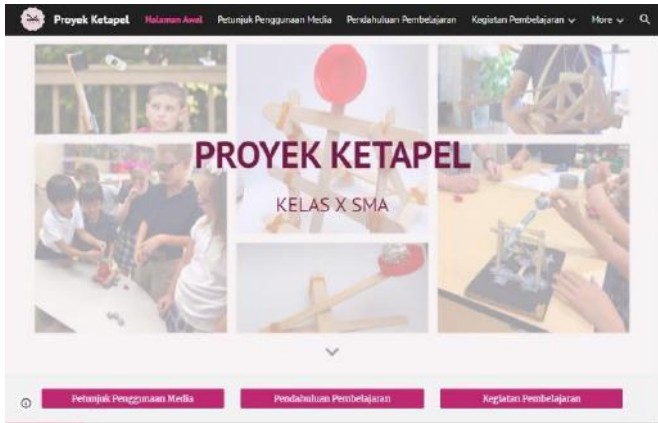
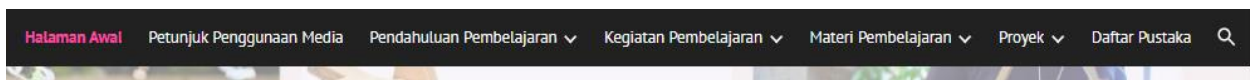


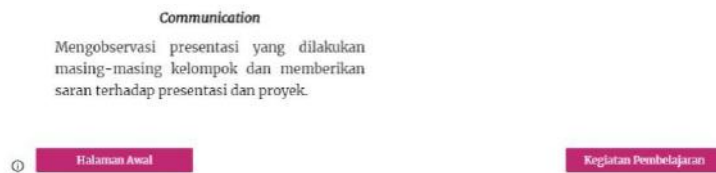
Fig.2. The homepage

The homepage showed the title and menu. On this page, users can go to the guidelines page, the introduction

page, the learning activities page, the course material page, the project page, and references. The guidelines page showed the media application. Meanwhile, the introduction page displayed the competencies, learning objectives, and learning stages. Furthermore, the learning activity page showed the learning activities complete with video. In addition, the course material page displayed theory for projectile motion. Besides, the project page displayed the catapult project to enhance the comprehension of projectile motion. The learning activities page displays the students' core activities. Finally, the references showed some references of projectile motion. The details were shown in figure 3 (a) and (b).



(a)



(b)

Fig.3. (a) The main menu, (b) The sub menu's button



Fig.4. Menu of learning activities

Figure 4 showed the three learning activities: kegiatan belajar 1 to 3. The learning activities are arranged based on five process stages of project-based learning STEM. In general, learning activities lead students to create the catapult project and do the presentation. Finally, the students present the project by integrating STEM as shown in figure 5.

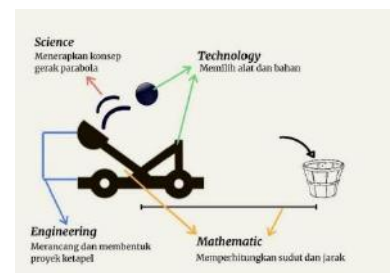


Fig.5. Example of students' project design

Moreover, before the learning media was implemented, the experts should validate it in material and media aspects. The material aspect consists of content, language,

and presentation. Meanwhile, the media aspect consists of design, user-friendly and visual communication. The validation results showed in the following table.

Table 2. The validation result of learning media by the experts

Aspects	Indicator	Score	Average	Criteria
<b>Material</b>	1. Contents	3.8	3.8	Excellent
	2. Language	4		
	3. Presentation	3.5		
<b>Media</b>	1. Design	3.3	3.3	Excellent
	2. User friendly	3.4		
	3. Visual communication	3.2		

Table 2 shows that the material and media validation results' average score was 3.8 and 3.32, respectively. Based on the criteria in table 1, the scores met the excellent category. Therefore the media can be applied for project-based learning STEM as an essential component in the learning process[20]. Besides, the media can help the students to comprehend the projectile motion in the form of a project. Finally, even though the results are excellent,

the validator recommended revising the typographical error in the media.

After the media revised, researcher implements the media to see how the response of students having studied with the project-based learning media. Students are given a questionnaire that consisted of 18 questions with aspect of material, media, and benefit. The questionnaire is filled 28 students in grade 10 secondary school. The results of responses by students shown in table 3.

Table 3. The students' response on project-based learning STEM

Aspects	Indicator	Score	Average	Criteria
<b>Material</b>	1. Learning material	3.6	3.6	Excellent
	2. Assignment	3.5		
	3. Resume	3.6		
	4. Presentation	3.6		
	5. Picture and video	3.6		
<b>Media</b>	1. Language	3.7	3.6	Excellent
	2. Layout	3.6		
	3. Typographical	3.7		
	4. Picture and video quality	3.7		
	5. Learning media interest	3.4		
<b>Benefit</b>	6. User friendly	3.7	3.5	Excellent
	1. Convenience	3.5		
	2. Interest	3.4		
	3. Motivation	3.5		

Table 3 showed results of students' responses which consist of material, media, and benefits aspects. The material aspect consisted of learning material, assignment, resume, presentation, picture, and video. At the same time,

the media aspect consisted of language, layout, typography, picture and video quality, learning media interest, and user friendly. Finally, the benefit aspect consisted of convenience, interest, and motivation. The

results were 3.6, 3.6, and 3.5 for material, media, and benefits aspects which were excellent.

#### IV. CONCLUSION

In the covid-19 pandemic, the learning process has changed from face-to-face to online learning. Digital media (google site) have been developed to enhance student comprehension in online learning. Here is project-based learning STEM media on the projectile motion for secondary school students. Several experts have been validated the media to evaluate it. The validation results showed that the media is excellent because the material and media aspect's average score was 3.8 and 3.3, respectively. Besides validation, the students' response was also excellent for material, media, and benefit criteria, with an average score of 3.6. Both validation and implementation results showed that the media was excellent. Therefore, the project-based learning STEM with a catapult project can be applied as a supplemented media for the projectile motion learning process and applied in online learning during the covid-19 pandemic.

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