

Development of TPACK based-physics learning media to improve HOTS and scientific attitude

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Abstract. 21st-century physics learning challenges teachers to teach physics that not only memorizes formulas, but is able to improve scientific attitudes and higher order thinking skills (HOTS). Technological, pedagogical, and content knowledge (TPACK) concept is considered capable of presenting this goal with technology integration. Researchers developed TPACK-based learning media that can improve HOTS and scientific attitudes using spreadsheet macros. This study uses the Define, Design, Develop, and Disseminate (4D) method. Media products have been proven to be able to develop HOTS and scientific attitude as seen from the value of N-gain in the medium category with score of 4 for HOTS and 6 for scientific attitude.

Keywords: *TPACK, HOTS, scientific attitudes*

1. Introduction

The Indonesian ministry of education and culture has familiarized the HOTS question to the students through the national examination. The government wanted the better result of PISA test. The level of Indonesian students in PISA test still at the lower level [1]. It is important because students will face the industrial revolution 4.0. In this era, students need to be prepared critical thinking skills, one of the 21st-century skills so students have to be able to adapt flexibly to changing situations, be sociable, work independently and think critically [2].

Teachers have to prepare their students to face this era. So physics learning activity also adapts to this condition. Learning physics will be not only about formula, but also motivated learning, content-based, and meaningful so the knowledge is useful for daily life [3]. It starts with the learning media. The characteristics of learning media must contain the application of physics in daily life, suitable with the characteristics of learners and digital-technology based. There is much research to combine the material content that is applicable in daily life, based on pedagogic knowledge and using technology to provide the interesting stimuli so students will be motivated to learn, this is the concept of TPACK based learning [4].

TPACK based learning activity gave the interesting physics learning activity, then we hope the learning would make the students not only understand the concept of physics but also can build their scientific attitude. These are the most important outcomes of science teaching [5]. There are three groups of scientific attitude, there are general attitude towards information (curiosity, skepticism, open-mindedness, antiauthoritarianism, creativity, and humility), attitudes to evaluate information (intellectual honesty, objectivity, and tendency making decisions), and scientific beliefs (truth loyalty, nature understandability, natural cause and effect relationships) [6].



The students' HOTS and scientific attitude can be improved with various learning media and learning model [7]. In this research, TPACK based-learning media was developed to improve scientific attitude [8]. The data of scientific attitude can be observed from learning activity [9]. Then the using of TPACK based-learning media would be observed by the instrument of observation. The media would use spreadsheet excel that there were mathematics calculation and interactive tools. Using spreadsheet, the data processing of mathematics calculating, table and graph are automatically like virtual lab [10]. The application of ICT like this can improve the motivation of students to learn physics [11]. The expensive tools or difficult problems often constrained learning physics can be overcome by simple simulation [12]. Then spreadsheet can be more interactive by developing visual basic for application (VBA). Physics teacher got this knowledge from university, but did not used it when teaching [13]. It is better to bring these potentials so learning activity will be more interesting and effective. Researchers developed the physics learning media based on TPACK using VBA to improve HOTS and scientific attitudes of higher school student.

2. Research method

Development of the media using the 4D method. First, we defined the media using the questionnaire to know the student needs in the learning activity to improve their HOTS and scientific attitude. This study involved fifty-one students and two teachers in ABBS High School. Second, we designed the media based on the result of the questionnaire and following the TPACK. The design was validated by the lecturers, teachers and peer reviewers. Third, we developed the media and then tried to the small and big group. The effectiveness of improving HOTS and scientific attitudes was examined by measuring the differentiate before and after using the media. Figure 1 shows the process to develop the media. The last step is to disseminate, we planned to disseminate this product to the schools in Surakarta.

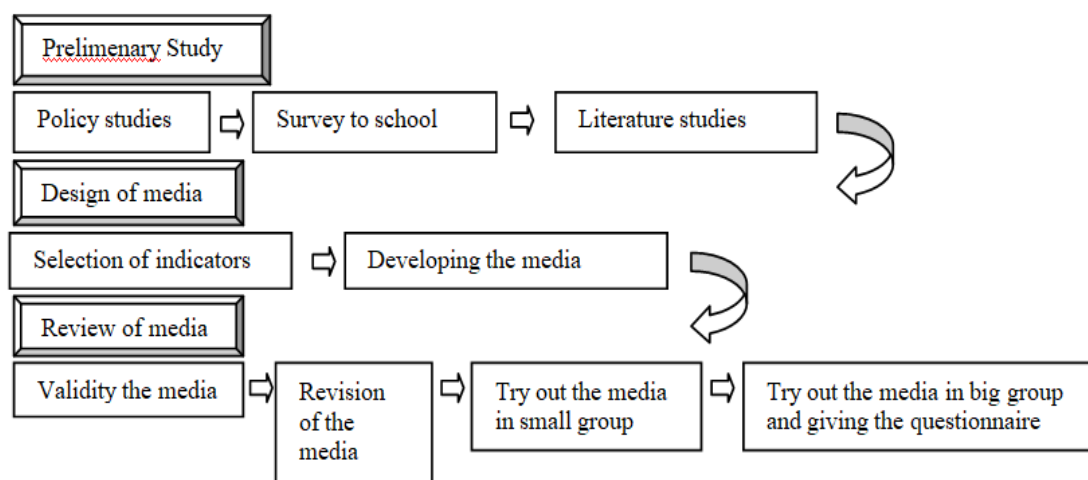


Figure 1. The process to develop the media.

3. Results and Discussion

3.1. Product validity

The product is validated by the experts as shown in table 1. Two lecturers who are the Ph.D. holders. Two physics teachers who graduated with honors from university and they also teach Olympiad. Two peer reviewers are the graduate student in Universitas Sebelas Maret who researches the development of instruments and modules.

Table 1. Background of expert.

Experts' title	Institution	Expertise
Lecturer (E1)	Universitas Sebelas Maret	Physics Learning Media, Physics Education, TPACK
Lecturer (E2)	Universitas Sebelas Maret	Computational Physics, Theoretical Physics
Peer reviewer (e3)	Universitas Sebelas Maret	Development of assessment instrument
Peer reviewer (e4)	Universitas Sebelas Maret	Development of physics module
Physics teacher (e5)	SMA ABBS Surakarta	Astronomy olympiad
Physics teacher (e6)	SMA ABBS Surakarta	Geosciences olympiad

Table 2 shows the experts' scores in the percentage calculation method. The total score indicated that the media can be used to improve HOTS and scientific attitude.

Table 2. Percentage of expert scores.

Items	E1	E2	E3	E4	E5	E6	Percentage
Suitable for Student	1	0	1	1	1	1	83%
Can be used in the class	0	1	1	1	1	1	83%
Can improve HOTS	1	1	1	1	1	1	100%
Can improve scientific attitude	1	1	1	1	1	1	100%
Total Score	3	3	4	4	4	4	91.5%

The next validation step was tried out to five students as the small group. Table 3 shows the students' judgment of usability and they gave the suggestion to decrease the numeric calculation then give the physics interpretation of the numeric calculation and to make better the display of the program. All of the suggestion has been used to revise the media before trying out to the big group of students in the class.

Table 3. The students judgment of small group to the media

Items	Judgement
Content	Applicative in daily life
Display	So many
Language interaction	Interactive
Experiment and exercise	Integrated

Researchers got the data of interviews with the teachers about the media, their learning activity and their knowledge about TPACK. Usually, they teach in the class with animation or virtual lab, but they did not understand about TPACK. Discussing TPACK with them by showing this media made them sure that it can be able to improve HOTS and scientific attitude. Figure 2 shows the display of the media. The media is like the virtual lab to processing simulation data and give us the graph to be analyzed by the student. This media also shows the observation of the projectile motion from the live experiment.

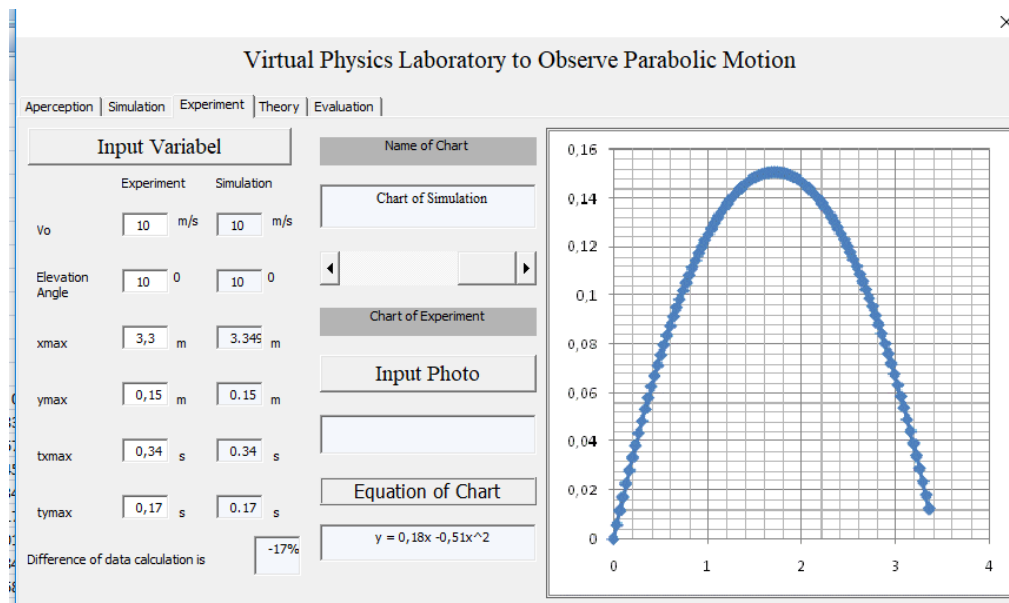


Figure 2. The Print screen of the media.

The indicators of scientific attitude which was arranged are curiosity, environmental awareness, open-mindedness, skepticism, perseverance, creativity, intellectual honesty, and critical thinking [6]. The final step of this research is dissemination. We distributed this product to ten schools then three of them have given the feedback. They gave the information that this product is relevant to apply in their school.

3.2 Product effectiveness

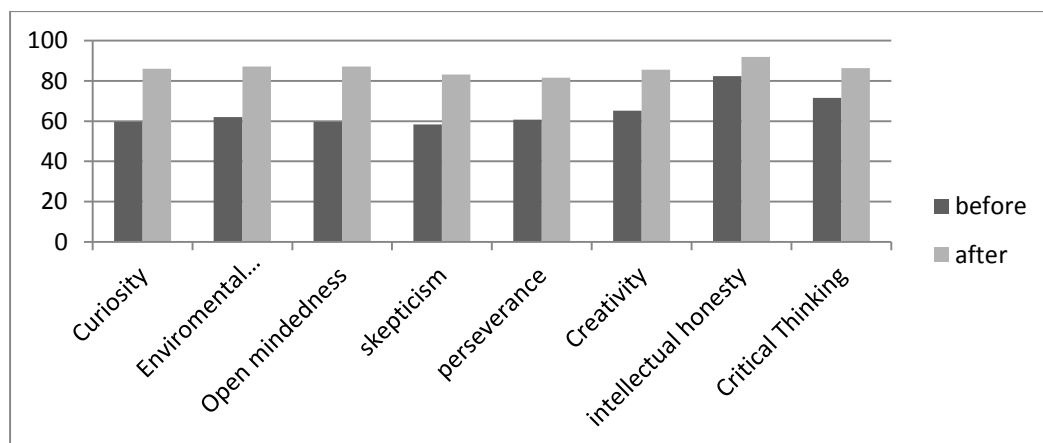


Figure 3. Chart of enhancement of scientific attitude.

Figure 3 shows that there is the enhancement of scientific attitude after using this learning media. The highest achievement was open-mindedness. Before using this learning media, some students assumes that physics is difficult. This learning media gave interesting learning activity so the students felt happy and enjoyed it. The assumption about physics changed to become a fun learning activity, not only about formula and calculation. This result is linear with the second-highest achievement, which is curiosity. Students started to love physics because of this media.

Table 4. Observation data.

Score Interval	Category	HOTS		Scientific Attitude	
		Pretest	Posttest	Before	After
100-76	Excellent	7.84 %	21.57 %	18 %	84 %
75-51	Good	11.76 %	60.78 %	66 %	16 %
50-26	Enough	31.37 %	31.37 %	16 %	0 %
25-1	Poor	47.06 %	0 %	0 %	0 %

The observation data of HOTS, we got from the two-tier multiple-choices that been used to measure HOTS [14], [15]. Table 4 shows that the frequency of scientific attitudes increase significant and there is no one in poor category after using this learning media. Then the average score of HOTS increased significant and there is no one in poor category at post-test results. The pre-test and post-test result gave N-gain score are 0.4. Then for scientific attitude with N-gain score is 0.6. The media could improve HOTS and scientific attitude as shown in previous research [6]-[9]

4. Conclusion

Students have to prepare to face revolution industrial 4.0 so teachers have to give their students the competency of the 21st century, as like critical thinking skills, be sociable and adapt flexibility in changing situations. These competencies can be developed by improving HOTS and scientific attitude. TPACK based learning is effective learning to do this in the physics learning activity. Researchers developed the physics learning media by visual basic for application. The media had been validated and tried out to the students. The media could improve HOTS and scientific attitude.

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