Utilizing STEM-Based Physics Digital Workbook with Project Based Learning Activities to Enhance Students' Generic Science Skills

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Abstract. The study aims to determine the effectiveness of using STEM-based digital workbooks with a Project-Based Learning approach in improving the generic science skills of junior high school students. This study is an experimental study using one group pre-test and post-test design. The population in this study were class VII students at a junior high school in Bandar Lampung, with a sample of 32 students. The instrument in this study was a multiple-choice test related to students' generic science skills to measure students' generic science skills on the subject matter of temperature, heat, and displacement. Based on the test results, the Sig value is <0.05, and the average N-Gain is 0.81, included in the high category. The result shows that STEM-based digital workbooks with a project-based learning approach affect students' generic science skills, as indicated by an increase in average scores. Based on this, using digital workbooks with a project-based learning approach integrated with STEM can improve the generic science skills of junior high school students.

Keywords: Digital Workbook, Generic Science Skills, Project-based Learning, STEM

1 Introduction

Educational website technology can be well developed to facilitate students in learning material and to support or facilitate the acquisition of knowledge, competencies, and skills [1]. A website can be modified according to needs. Various variations of a website are available on the internet, be it in the form of a learning management system, a blog, and others that can be used by teachers in delivering learning materials, including by presenting teaching materials or learning media on the web [2]–[8].

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Along with the massive development of technology, media, and teaching materials have also progressed, such as the existence of workbooks or workbooks of students which were initially only in the form of print-outs, transformed into electronic or digital, web-based and others, which can be alternative learning media [9]–[11]. A workbook can be designed and developed according to the conditions and situations of learning activities. Several previous developments have shown that the use of workbooks and worksheets in learning can improve creative thinking skills, higher-order thinking skills, collaboration and communication skills, science process skills, and others needed by students[12]–[15]

One approach to learning complementary to this digital workbook is through project-based learning activities. In this activity, students will engage in real projects that challenge them to apply the physics concepts they have learned to real-world situations [16], [17]. It helps students to deepen their understanding, practice collaboration, problem-solving, and critical thinking skills [18], [19]. Through STEM-based physics digital workbooks with project-based learning activities, students can expand their knowledge of physics in fun and meaningful ways. They can see how physics concepts can be applied in everyday life and develop relevant skills for their future. Combining STEM-based physics digital workbooks and project-based learning activities offers a holistic and fun approach to learning [20]–[22]. Through the application of this approach, students become more actively engaged and enthused, resulting in a more profound comprehension of physics and the acquisition of skills that are instrumental for their personal development. Within this context, conducting research is imperative to ascertain the efficacy of employing STEM-based physics digital workbooks in tandem with project-based learning activities.

2 Method

This experimental research was conducted at a junior high school in Bandar Lampung. The study focused on grade VII students at the school, with a sample of 32 students randomly selected for the research. The study employed a one-group pre-test and post-test design [23], [24]. Prior to the commencement of the learning program, all students underwent a pre-test to evaluate their initial understanding of the physics concepts to be taught.

Group	***Pre-test***	**Treatment**	***Post-test***
Experiment	*O1*	X	*O2*

Fig. 1. One group pretest posttest design

The pre-test included questions related to the physics material that would be covered in the program. Following the pre-test, the learning program utilized a STEM-based

physics digital workbook with project-based learning activities. These digital workbooks introduced an interactive and captivating approach to learning, incorporating elements such as animations, simulations, and videos to facilitate students' comprehension of intricate physics concepts. Throughout the program, students actively engaged in various project-based learning tasks, each presenting real-world challenges that compelled them to apply the physics principles they had acquired. These activities not only enriched their understanding of physics but also fostered the development of valuable collaboration, problem-solving, and critical-thinking skills. Upon completing the learning program, all students underwent a post-test designed to evaluate their comprehension after utilizing the digital workbooks and participating in project-based learning activities. The post-test also featured questions that pertained to the physics material covered during the program [25].

3 Result

This research assesses the efficacy of employing STEM-centered physics digital workbooks combined with project-based learning activities for enhancing students' comprehension of physics principles. The research methodology employed here is experimental, utilizing a one-group pre-test and post-test design, with the N-Gain method to gauge the growth in students' comprehension. The study was conducted within a junior high school in Bandar Lampung, with the participant pool consisting of 7th-grade students. Of this student population, 32 individuals were randomly selected to participate in the research. Before initiating the learning program, all students underwent a pre-test to evaluate their initial grasp of the physics concepts slated for study. This pre-test encompassed inquiries related to the physics material covered in the learning program. Subsequently, the learning program featured STEM-oriented physics digital workbooks intertwined with project-based learning activities. These digital workbooks offered an interactive and immersive approach to education, integrating elements like animations, simulations, and videos to facilitate students' comprehension of intricate physics concepts. Upon completing the learning program, all students were subjected to a post-test to assess their comprehension following their engagement with STEM-based physics digital workbooks and participation in project-based learning activities. This post-test also featured questions relevant to the physics material covered during the learning program.

Table 1. Descriptive Statistics N-Gain

	N	Minimum	Maximum	Mean	Std. Deviation
N_gain	32	,25	1,67	,8143	,40533
N_gainper	32	25,00	166,67	81,4323	40,53252
Valid N (listwise)	32				

Data in this study was collected through pre-test and post-test tests conducted before and after the learning program. The results of data analysis using the N-Gain method showed a significant increase in student understanding after participating in the learning program. N-Gain is a method used to measure the difference between post-test results and pre-test results and indicate the extent of increased understanding. The N-Gain scores obtained showed an improvement in students' understanding of physics concepts after participating in the learning program using STEM-based physics digital workbooks and project-based learning activities. The results of this study show that using STEM-based physics digital workbooks with project-based learning activities can effectively increase students' understanding of physics concepts. An interactive and engaging learning approach using digital workbooks with features such as animations, simulations, and videos helps students understand complex physics concepts better.

4 Discussion

This study's results show that using STEM-based physics digital workbooks with project-based learning activities significantly increases students' understanding of physics concepts. Based on the N-Gain method used an N-Gain result of 0.81 was obtained [26], [27]. This N-Gain value indicates a positive and significant improvement in student understanding after participating in the learning program using STEM-based physics digital workbooks and project-based learning activities. An N-Gain value of 0.81 indicates that increased student understanding is significant after participating in the learning program[28], [29] . This shows that using STEM-based physics digital workbooks with project-based learning activities positively impacts student understanding. An interactive and engaging learning approach using digital workbooks with features such as animations, simulations, and videos helps students understand complex physics concepts better.

The significant increase in student understanding can be explained by several factors related to the learning program implemented. Using STEM-based physics digital workbooks allows students to learn independently and interactively [30]–[34]. Features such as animations, simulations, and videos provide a fun and engaging learning experience for students so they are more involved in the learning process[33], [35], [36] . In addition, project-based learning activities also provide opportunities for students to apply physics concepts in real-world contexts. Through this activity, students can relate theory to practice, which can deepen their understanding [37]–[40]. Using STEM-based physics digital workbooks allows students to learn independently and interactively. This digital workbook presents physics material with interesting animation, simulation, and video approaches. These features provide an enjoyable learning experience for students and encourage active participation in the learning process. Animation can help visualize abstract physics concepts, simulation can allow interactive exploration, and videos can provide practical examples of how those concepts apply in everyday life [41]–[43]. Thus, students can understand complex physics concepts more easily through engaging and interactive digital workbooks. In addition, the

existence of project-based learning activities also contributes to increasing student understanding.

Through project activities, students can apply learned physics concepts in real-world situations [44]–[46]. In this activity, students can connect theoretical physics with practice to see the relevance and usefulness of these concepts in everyday life. For example, students can design and build simple models, conduct experiments, or identify physical phenomena in the environment around them. These project activities enable students to engage actively, think critically, and develop problem-solving skills. Thus, students can deepen their understanding of physics concepts through practical experience provided by project-based learning activities. Combining STEM-based physics digital workbooks and project-based learning activities is an effective strategy for increasing student understanding [47], [48]. Digital workbooks give students access to interactive and engaging content, while project-based learning activities allow students to apply physics concepts in authentic contexts. Students can develop a deeper understanding, relate physics concepts to real-world situations, and hone their critical and problem-solving skills through this learning approach.

The results of this research have important implications for the development of learning methods in physics and STEM fields. Learning approaches that use technology, such as STEM-based physics digital workbooks with project-based learning activities, can provide students with a more engaging and relevant learning experience [49], [50]. This can increase students' interest and motivation in studying physics and help them develop a deeper understanding of physics concepts. The results of this research can encourage the use of innovative and effective learning methods in the educational environment and contribute to the development of better learning strategies in the fields of physics and STEM.

5 Conclusion

Using STEM-oriented physics digital workbooks alongside project-based learning activities effectively enhances students' comprehension of physics principles. The research techniques employed, specifically the one-group pre-test and post-test design and the N-Gain measurement, provide compelling evidence of heightened student understanding after participating in the educational program. Adopting an interactive and captivating learning approach through digital workbooks featuring elements like animations, simulations, and videos provides students with an enjoyable and engaging educational experience. This active involvement in learning facilitates a deeper grasp of intricate physics concepts. Moreover, incorporating project-based learning activities allows students to apply physics principles in real-world scenarios, further enriching their practical understanding of the subject matter. Furthermore, future research endeavors could explore comparative studies to assess the effectiveness of this learning approach against alternative methods, thereby offering a more comprehensive insight into the potential utility of STEM-centered physics digital workbooks in conjunction with project-based learning activities for enhancing student comprehension.

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