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The Development of Project-based Learning Instrument Assisted by Lego® Mindstrom®

Dara Puspitasari [1,*], Toni Kus Indratno [2]

[1, 2] Department of Physics Education, Universitas Ahmad Dahlan

ABSTRACT

An alternative solution to using STEM (Science, Technology, Engineering, and Mathematics) in learning is - by offering relevant contextual learning and integration of STEM knowledge via project-based learning with an educative robot kit as the learning instruments. This research developed a project-based learning instrument assisted by Lego® Mindstorm®, implemented by teachers in a physics lesson, specifically on friction material. The research's novelty dealt with the use of Lego® Mindstorm® as the visual aid with the STEM approach. This research used Borg & Gall's Research & Development model, consisting of 10 stages. The researchers focused this R&D only on student worksheets and lesson plans. In this research, the researchers involved five experts in judging the reliability of the learning instruments: the student worksheet and lesson plan applied in the learning process. The validation result of the developed student worksheet showed that the reliability judgment of material expert was 94.6%, while the expert of media with 79.7%. Then, the lesson plan's validation result was 76% based on the material expert's judgment. Then, the validation result of the evaluation instrument indicated an excellent category. Thus, the learning instruments were reliable to be implemented in the classroom to facilitate teachers in optimizing the learning technology.

INTISARI

Penelitian ini bertujuan untuk menyediakan perangkat pembelajaran berbasis proyek berbantuan Lego® Mindstorm® yang siap diimplementasikan oleh pendidik di sekolah, khususnya pada pembelajaran fisika pada pembahasan materi Gaya Gesek untuk siswa kelas X. Hal baru yang ada pada pembelajaran menggunakan perangkat ini terletak pada penggunaan Lego Mindstorm sebagai peraga dengan pendekatan STEM. Pengembangan yang dilakukan mengacu pada prosedur penelitian Borg and Gall. Hasil validasi ahli menunjukkan bahwa perangkat pembelajaran berupa LKPD dan RPP yang telah dikembangkan layak untuk digunakan dalam proses pembelajaran. Hal ini ditunjukkan oleh hasil validasi ahli untuk LKPD dari ahli materi yang memperoleh hasil 94,6% dan ahli media 79,7% dengan skala likert. Sedangkan hasil validasi ahli media untuk RPP menunjukkan hasil 76% dengan skala likert. Kemudian hasil validasi instrumen evaluasi dinyatakan dalam kategori baik. Perangkat pembelajaran ini diharapkan dapat diimplementasikan di kelas dan membantu pendidik dalam mengoptimalkan teknologi pada pembelajarannya.

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* Corresponding author:
Dara Puspitasari, Department of Physics Education, Universitas Ahmad Dahlan, Indonesia.
✉ dara1600007056@webmail.uad.ac.id

A. Introduction

Current education patterns bring challenges for educators to prepare and facilitate their learners to compete in this opened-information era of the 21st century. Nowadays, learners must master four basic competencies, critical thinking and problem solving, creativity, communication, and collaboration [1]. In Indonesia, education also encounters challenges of the 5.0 Society era that demands new learning patterns in classrooms.

The 5.0 society refers to "smart community," a term proposed by the Japanese cabinet in 2016. This term describes the situation in which people encounter virtual-physical integrated word technology [2]. The 5.0 society technology also develops artificial intelligence with Big Database and robots to promote and support human's jobs. Salgues [3] explains that industrial development plan during 5.0 society includes big data, cloud computing, augmented reality, e-education, and robotics. These development influence all sectors, including education [4]. The influence of 5.0 society in the educational field encourages the importance of new literacy to prepare more competitive graduates. Thus, the generation will be ready to deal with the 5.0 society era.

This new literacy movement includes analysis, digital data literacy, engine mechanism understanding, and new technology skills. New technology applications deal with coding, artificial intelligence, engineering principle, communication, and design, or human literacy [5]. However, education in Indonesia has shown a satisfying result because of a decreased indicator from 2015, based on PISA sore data (Programme for International Student Assessment) in 2018 [6]. Figure 1 shows the PISA Lesson Score in Indonesia from 2012, 2015, and 2018.

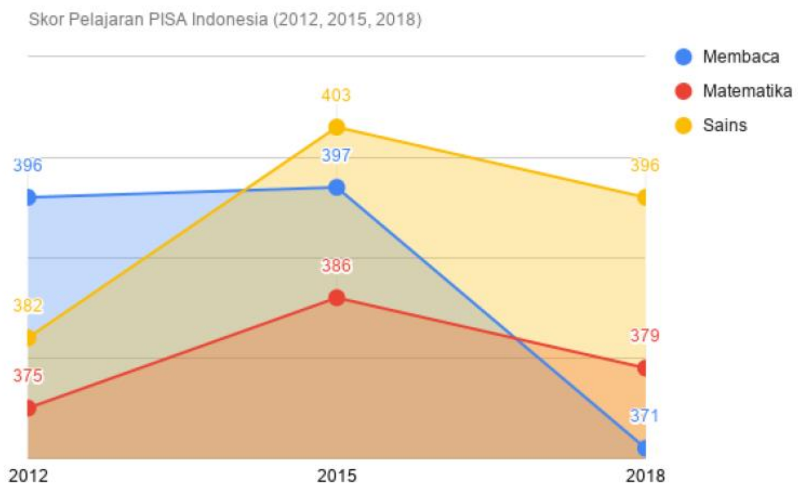

Figure 1. The PISA Lesson Score in Indonesia from 2012, 2015, and 2018
Source: www.zenius.net/blog/23169/pisa-20182-2019-standar-internasional

Figure 1 shows the PISA lesson scores in Indonesia decreased from 2015 until 2018. This score decrease includes three aspects: reading, mathematics, and science. The decrease of these three aspects becomes a concern for our education. Thus, it is important to improve student's literacy skills.

One of them is by providing various learning and integrating science, language, and mathematic literacy based on the students' needs. STEM (Science, Technology, Engineering, and Mathematics) could be a science learning alternative. STEM is a learning approach designed to combine science, technology, engineering, and mathematics to understand nature. The approach design aims to apply and practice the principles of STEM for learners to deal with daily life.

Sagala et al. [7] found that physics learning with STEM effectively improved learners' creativity. STEM in physics learning could facilitate learners to use technology and integrate the experimental activity. Thus, they can prove a law or conceptual knowledge. However, the researchers found teachers still found difficulties in using STEM in their learning.

An alternative solution to using STEM (Science, technology, engineering, and mathematics) in learning is by offering relevant contextual learning and integration of STEM knowledge via project-based learning with an educative robot kit as the learning medium. Project-based learning involves learners' activity to learn. Learners can use a robotic kit. They can assemble the robotic kit to stimulate their concepts and thinking methods in a STEM field. A robotic kit is also useful for allowing learners to participate in the learning process and develop their computational thinking skills. A robotic kit has a certain program to run or combine related activities with physics concepts, such as force and mass, velocity and distance, and friction. On the other hand, educators also encounter difficulties designing the learning by optimizing technology and involving learners' activity in the learning process. Thus, the educators require learning an instrument to facilitate the learning implementation in the classroom.

Therefore, this research developed project-based learning assisted with a robotic kit. In this research, the researchers used a robotic kit as a learning medium to adopt the STEM approach based on Khoiriyah's [8] definition of STEM literacy (see Table 1). The applied robotic kit in this research was Lego® Mindstorm® EV3. This robotic kit was an educative kit to train STEM skills. Lego® Mindstorm® EV3 has some sensors, such as gyroscopic sensor, angular size sensor, and distant measurement sensor. In this research, the researchers used material about friction for tenth graders. The researchers invited the learners to assemble a robot of Lego® Mindstorm® EV3. Then, they experimented to determine the static friction coefficient.

Table 1. STEM Definition

Literacy	Definition
Science	Skills to identify scientific information and to apply the information in the real world in seeking a solution
Technology	Skills to use, develop, and analyze various influential technologies toward learners' cognition
Engineering	Skills to develop a more creative and innovative technology design by combining various disciplines and creating a relevant concept with real-world for learners
Mathematics	Skills to analyze and deliver notion, formulation, and solution mathematically along with the applications

For most physics classroom lessons, both teachers and learners perceive the static and kinetic friction coefficients as the given measurement without doing experiments. Physics teachers tend to only note the static and kinetic friction coefficients from the learning sources without further information for learners about discovering the coefficients. This difficulty was due to a complex experiment to determine friction coefficient, especially in an inclined plane. An accurate direct observation was useful to report the angular size of the inclined plane when an object would move. It was useful to determine the static friction coefficient. Besides that, the manual measurement used a stopwatch to determine the sliding-traveling time of an object in a relatively short track. These complexities of determining friction coefficient require solutions involving an educative robotic kit with Lego® Mindstorm® EV3.

B. Method

This Research & Development used Borg & Gall's model. The model consisted of ten stages: 1) research and information collection; 2) planning; 3) develop a preliminary form of product; 4) preliminary field testing; 5) main product revision; 6) main field testing; 7) operational product revision; 8) operational field testing; 9) final product revision, and 10) dissemination and implementation. This research only focused on the sixth stage [9]. However, the developed product had been revised in the previous stages. The results of product revision showed the product was reliable to use.

In this research stage, the researchers involved lecturers and teachers as the field experts. The other experts were content material, media, and evaluation experts. The applied instruments in this research were (1) content material evaluation sheet to determine the suitability of the material in worksheet, (2) evaluation sheet of media experts to determine the worksheet and lesson plan, and (3) evaluation sheet for evaluation experts to obtain information about evaluation instrument quality of the developed learning instruments. The developed learning instruments were only a lesson plan and worksheet. The obtained data in this research included: (1) validation data of the product judgment by a content material expert, (2) validation data of product judgment by a design material expert, and (3) validation data of evaluation instrument judgment by an evaluation expert.

C. Result and Discussion

Researching and collecting information

In this stage, the researchers identified the problems by observing the classroom learning, interviewing the lesson teacher, and reviewing previous studies about learning promotion with technology use optimization at school. The identification results showed some potentials and problems, such as teachers' difficulties in designing learning with optimized technology and active participation of the learners. On the other hand, the teachers and learners perceived the material about static and kinetic frictions already had the given measurements. Thus, they thought it was not important to further experiment on the measurement. They also thought the experiment about friction coefficient was complicated and required accurate observation to report the angular size of a moving object. The researchers used Lego® Mindstrom® as a learning medium. However, the teachers and learners were not familiar with this learning medium. Therefore, the researchers developed learning instruments by integrating technology and active participation in student worksheets. The researchers also attached the lesson plan in project-based learning and prepared Lego® Mindstrom® as the learning medium.

Designing the product

In this stage, the researchers designed the learning materials, such as core competence, learning objective, and indicator of competence achievement. Then, the researchers designed the learning instruments in the form of student worksheets and lesson plans.

The initial product development design

The learning instruments were the lesson plan and student worksheet in this stage. The researchers developed the learning instruments based on the applied guideline. The important development parts were designing the student worksheet attachment, designing the learning stages, and determining the instrument to measure or evaluate the learning outcomes in the form of a test. The researchers provided the student worksheet attachment in a Quick Response Code or QR-code to attract the learners. QR-code is a two-dimensional code to collect, store, and display information. Then, the applied learning stages were STEM-Pjbl syntax [10]. It consisted of five stages: reflection, research, discovery, application, and communication. The researchers adjusted the evaluation instrument with the learning objectives. The realizations of the evaluation instrument were multiple choice and essay.

Initial field test/product validation

The researchers invited experts, material, and media experts to judge the developed learning instruments. On the other hand, the researchers invited an evaluation expert to judge the evaluation instrument. The judgment or validation processes used an observational instrument with the Likert scale. The observational results were suggestions and recommendations. The researchers tested the product reliability with two material experts, three media experts, and two evaluation experts. Table 2 shows the validation or judgment results.

Table 2. Experts' Judgment

Number	Instruments	Experts	Percentage (%)	Categories
1	Lesson Plan	Media Expert	76.00	Very Excellent
2	Student Worksheet	Media Expert	79.70	Very Excellent
		Material Expert	94.60	Very Excellent
Mo3	Evaluation Instrument	Evaluation Expert	55.30	Excellent

Product Revision

After judging the product, the experts shared suggestions and recommendations to revise the developed product. Here are the inputs for further revisions:
1) the student worksheet should describe diagrams about force as the materials;
2) the lesson plans should describe the activities;
3) the student worksheet should provide report-writing instructions;
4) the developed product should present learning outcome assessment and learning evaluation.

Limited test

After revising the product, the researchers tested the product for X graders of SHS that received physics lessons with friction. The researchers promoted this stage online due to the COVID-19 pandemic spread preventive regulation.

D. Conclusion

The researchers developed the learning instruments with a project-based learning model assisted by Lego® Mindstorm® for a physics lesson with friction. The learning instruments were student worksheets and lesson plans. The content material and media experts judged the worksheet very excellent. The media expert also judged the lesson plan very excellent. For the evaluation instrument, the evaluation expert judged it excellent. Thus, the applied learning instruments in this research were reliable for the teaching-learning process.

References

[1] C. Kivunja, “Do you want your students to be job-ready with 21st century skills? Change pedagogies: A pedagogical paradigm shift from vygotskyian social constructivism to critical thinking, problem solving and siemens' digital connectivism,” *Int. Journal of High. Edu.*, vol. 3, no. 3, pp. 81-91, 2014.

[2] I. Tussyadiah, “A review of research into automation in tourism: Launching the annals of tourism research curated collection on artificial intelligence and robotics in tourism,” *Annals Tourism Res.*, vol. 81, no. 1, pp. 102-109, 2020.

[3] B. Salgues, “Society 5.0: Industry of the future, technologies, methods, and tools, first,” London: ISTE Ltd and John Wiley & Sons, Inc, 2008.

[4] R. L. Lamb, L. Annetta, J. Firestone, and E. Etopio, “A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations,” *Comp. Human Behav.*, vol. 80, no. 1, pp. 158-167, 2018.

[5] B. Cope, M. Kalantzis, and D. Searsmith, “Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies,” *Edu. Philo. Theory*, vol. 1, no. 1, pp. 1-17, 2020.

[6] N. Mutowiah, E. Supriana, and S. Sutopo, “Pengaruh pembelajaran inkuiri terintegrasi STEM terhadap kemampuan kreativitas siswa,” *J. Riset Pend. Fis.*, vol. 5, no. 2, pp. 125-128, 2020.

[7] R. Sagala, R. Umam, A. Thahir, A. Saregar, and I. Wardani, “The effectiveness of STEM-based on gender differences: The impact of physics concept understanding,” *European J. Edu. Res.*, vol. 8, no. 3, pp. 753-761, 2019.

[8] N. Khoiriyah, A. Abdurrahman, and I. Wahyudi, “Implementasi pendekatan pembelajaran STEM untuk meningkatkan kemampuan berpikir kritis siswa SMA pada materi gelombang bunyi,” *J. Ris. Kaji. Pend. Fis.*, vol. 5, no. 2, pp. 53-60, 2018.

[9] L. Rohmaini, N. Netriwati, K. Komarudin, F. Nendra, and M. Qiftiyah, “Pengembangan modul pembelajaran matematika berbasis etnomatematika berbantuan wingeom berdasarkan langkah Borg and Gall,” *Teorema: Teo. Riset Mat.*, vol. 5, no. 2, pp. 176-186, 2020.

[10] S. Kusumaningrum and D. Djukri, “Pengembangan perangkat pembelajaran model project based learning (PjBL) untuk meningkatkan keterampilan proses sains dan kreativitas,” *J. Inov. Pend. IPA*, vol. 2, no. 2, pp. 241-249, 2016.