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DEVELOPMENT OF A PBL-BASED E-MODULE ON WORK AND ENERGY MATERIAL INTEGRATED WITH NUTRITION TO IMPROVE COGNITIVE LEARNING OUTCOMES OF 10TH GRADE STUDENTS

Ratu Mulyanengsih¹, Isna Juita Nurhidayah², Muhammad Dzakiruddin³, Yessi Crosita Octaria⁴

¹State Senior High School 30 Jakarta, Jl. Jenderal Ahmad Yani, Central Jakarta, 10510, Indonesia

^{2,3,4}UPN Veteran Jakarta, Jl. R.S Fatmawati, South Jakarta, 12450, Indonesia

*Corresponding Author E-mail: nengrat34@gmail.com

Abstract: Almost one third of Indonesian adolescents aged 15-18 years old are stunted, while many also have overweight and obesity problem. Nutrition education can be done by integrating nutritional information and concepts into certain subjects, one of which is physics. Subject in physics which in line with the concept of nutrition are work and energy. In work and energy subject, it discusses the concept of the relationship between work, energy, the law of conservation of energy, the concept has strong relationship with nutrition which is a source of energy needed to do work. This research is a development research with the ADDIE model, which has 5 stages, Analyze; (2) Design; (3) Develop; (4) Implement; and (5) Evaluate [19]. The purpose of this study is "Produce feasible and effective PBL e-module learning media to improve learning outcomes and increase understanding of the importance of nutritional intake among adolescents", which can be accessed on smartphones. The e-module was tested on 36 grade X MIPA students at SMAN 30 Jakarta. The study was conducted from March to October 2022. The method used is a quasi-experimental method using a pretest-posttest control group design. The media is validated by media experts and material experts using instruments. Based on the calculation of validation of media experts and material experts on the PBL-based nutrition-integrated business and energy (E-MUEGIZ) E-module, it is included in the very valid category, meaning that the media is suitable for use. While Based on the value of N-Gain it can be said that the E-Module of effort and energy integrated nutrition (E-MUEGIZ) can increase understanding of the importance of nutrition as a source of energy.

Keywords: Cognitive Learning; E-Module Development; Problem Based Learning; Effort and Energy, Nutrition.

Abstrak: Angka prevalensi stunting pada remaja usia 15 – 18 tahun berdasarkan riskesdas 2018 masih 29,6%. Selain, stunting remaja Indonesia juga mengalami masalah gizi lebih dan obesitas. Salah satu upaya pencegahan yang dapat dilakukan adalah melalui Pendidikan gizi. Upaya ini dapat dilakukan dengan mengintergrasikan informasi dan konsep gizi ke dalam mata pelajaran tertentu, salah satunya adalah mata pelajaran fisika. Materi fisika yang sejalan dengan konsep gizi adalah materi usaha dan energi. Dalam materi usaha dan energi membahas konsep tentang hubungan antara usaha, energi, hukum kekekalan enegi, konsep tersebut memiliki keterkaitan dengan gizi yang merupakan sumber energi yang dibutuhkan untuk melakukan aktivitas manusia. Penelitian ini merupakan penelitian pengembangan dengan model ADDIE, yang memiliki 5 tahapan, yaitu: (1) Analyze; (2) Design; (3) Develop; (4) Implement; dan (5) Evaluate [19]. tujuan dari penelitian ini adalah " Menghasilkan media pembelajaran e-modul PBL yang layak dan efektif untuk meningkatkan hasil belajar dan meningkatkan pemahaman akan pentingnya asupan gizi di kalangan remaja", yang dapat diakses pada smartphone. E-modul diuji coba kepada 36 siswa kelas X MIPA di SMAN 30 Jakarta. Penelitian dilaksanakan dari

bulan Maret sampai dengan oktober 2022. Metode yang digunakan adalah metode eksperimen semu (quasi experiment) dengan menggunakan rancangan pretest-posttest control group design. Media di validasi oleh ahli media dan ahli materi dengan menggunakan instrumen. Berdasarkan perhitungan validasi ahli media dan ahli materi terhadap E-Modul usaha dan energi yang terintegrasi gizi (E-MUEGIZ) berbasis PBL rmasuk dalam katagori sangat valid berarti media layak digunakan. Sedangkan Berdasarkan nilai N-Gain dapat dikatakan bahwa E-Modul usaha dan energi yang terintegrasi gizi (E-MUEGIZ) berbasis PBL efektif dalam meningkatkan hasil belajar kognitif siswa. Dan berdasarkan tanggapan siswa, modul E-MUEGIZ dapat meningkatkan pemahaman pentingnya gizi sebagai sumber energi.

Kata-kata Kunci: Belajar Kognitif; Pengembangan E-Modul; Problem Based Learning; Usaha dan Energi, Gizi

INTRODUCTION

In the era of technology, the behavior of teenagers, who tend to be less active and fond of consuming junk food, is increasing. Data from the Basic Health Research (RISKESDAS) in 2018 regarding the nutritional status of adolescents in Indonesia shows that 8.7% of adolescents aged 13-15 years and 8.1% of adolescents aged 16-18 years are classified as underweight or severely underweight. Meanwhile, 16.0% of adolescents aged 13-15 years and 13.5% of adolescents aged 16-18 years are classified as overweight or obese. The prevalence of nutritional status among adolescents aged 16-18 years in DKI Jakarta, according to the 2018 RISKESDAS data, is as follows: 1.89% are severely underweight, 7.03% are underweight, 12.76% are overweight, 8.29% are obese, and 70.04% have normal nutritional status.

Malnutrition is a concerning health issue, especially in developing countries, with children being the primary victims (Sinaga & Simanjuntak, 2020). More critically, malnutrition can lead to a child losing their life. In addition to discussing obesity and malnutrition, another concerning nutritional problem is "stunting." Stunting is a significant nutritional issue in Indonesia. The prevalence of stunting reached 29.6% in 2017 (Yadika et al., 2019). Stunting is a chronic condition marked by growth failure and subsequent cognitive and pathological abnormalities (Prastia & Listyandini, 2020).

Obesity is defined as an excessive accumulation

of fat in the body, primarily caused by an excessive calorie intake (Bakti et al., 2021). The weight of obese individuals becomes abnormal and can potentially lead to various diseases. Additionally, obesity can have psychological impacts on a child, which can persist into adulthood (Kenanti, 2021). Obese children may feel self-conscious and even ashamed when they interact with their peers. Furthermore, obesity can lead to various health issues, including sleep apnea, asthma, breast cancer, fatty liver, gallbladder disease, kidney disease, prostate cancer, varicose veins, stroke, type 2 diabetes, coronary heart disease, hypertension, colon issues, abnormal reproductive hormones, polycystic ovary syndrome, knee and hip osteoarthritis, gout, and high uric acid levels (Kemkes, 2020).

Dietary patterns are the most critical behavior that can affect nutritional status. This is because the quantity and quality of food and beverages consumed can influence nutrient intake, which, in turn, affects the health of individuals and communities. Optimal nutrition is essential for normal growth and physical and cognitive development in infants, children, and people of all age groups (Kemkes, 2014). Dietary patterns involve regulating the type and quantity of food consumed to maintain body condition, health, and protection against diseases (Amirullah et al., 2020). Dietary patterns are closely related to the nutrients needed by the body, as nutrients are substances required for supporting growth and development.

Based on previous research, it has been shown that media promotion of nutrition can increase

students' knowledge and behavior regarding nutrition (Kurdanti et al., 2019). The use of posters as a means of promoting nutritional awareness has also been found to be effective in communicating nutritional messages and is well-received by parents (Winingsih & Sulandjari, 2020). Research on the relationship between awareness and knowledge of nutrition and health awareness on the nutritional status of adolescents in Jakarta has shown that a majority of respondents (more than 50%) have normal nutritional status with sufficient knowledge of nutrition and moderate health awareness (Zerlina & Humayrah, 2023).

Given these nutritional issues and the results of previous research, it is necessary to develop strategies to increase understanding of the importance of nutritional intake in daily activities, especially among adolescents. This research aims to develop a physics e-module with a Problem-Based Learning (PBL) model integrated with nutrition and accessible through smartphones. This will provide an engaging and interactive way to present the importance of nutritional intake and enhance the cognitive learning outcomes of physics for 10th-grade students. The key competencies addressed by this e-module include KD 3.9, which involves analyzing the concepts of energy, work, the relationship between work and energy, the law of energy conservation, and its application in everyday events, as well as KD 4.9, which focuses on applying the scientific method to propose solutions for motion-related problems in daily life, related to the concepts of energy, work, and the law of energy conservation. These competencies are achieved by integrating nutrition into the physics learning materials on work and energy.

RESEARCH METHODOLOGY

The research target is directed towards the 10th-grade students in the Science Program (MIPA) at SMAN 30 Jakarta. The method used in this research is the Research and Development (R&D) method. The media development method employed in this research to develop the module is based on the ADDIE development model. The ADDIE model consists of five stages, which are:

- (1) Analyze; (2) Design; (3) Develop; (4) Implement; and (5) Evaluate (Branch,

2009). The representation of this model is illustrated in the schematic diagram below:

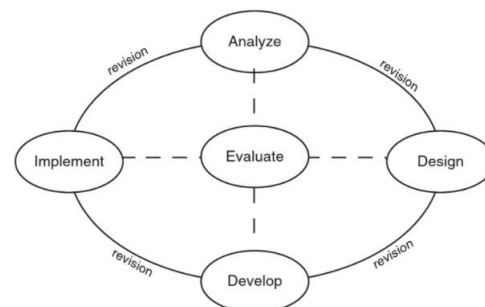


Figure 1. Stages of the ADDIE Model (Branch, 2009)

In the implementation phase, the research is conducted quantitatively by assessing the students' awareness of nutrition using a Likert scale based on the questionnaire distributed to the students. The research is carried out over a period of eight months, from March to October 2022.

RESULTS AND DISCUSSION

Development of E-Module

Based on the instructional materials development guideline published According to the Ministry of Education's guidelines (Diknas), a module is defined as a book written with the aim of enabling learners to study independently, either with or without the guidance of a teacher. To create a good and proper module, one of the most crucial aspects to understand is the structure of instructional materials. A module should contain at least seven components: title, instructional materials (student or teacher guidebook), the competencies to be achieved, supporting information, training, work instructions or worksheets (LK), and evaluation (Suprpto et al., 2021). Modules can be presented in either printed or electronic form.

Electronic modules are effective in delivering information about learning materials to learners. Learners are more engaged and enthusiastic when using e-modules, especially in physics education (Suprpto et al., 2021).

The development of this physics e-module uses the Problem-Based Learning (PBL) model with several syntaxes, namely: (1) Problem orientation; (2) Integrating students for learning; (3) Guiding investigations; (4) Developing and presenting results; (5) Analyzing and evaluating. The stages within PBL can guide learners in problem-solving (Suprpto et al., 2021).

The syntax of PBL-based learning is

conceptualized in a research-based ADDIE (Analysis, Design, Development, Implementation, and Evaluation) framework. The ADDIE stages used in this research are as follows, with a more detailed description:

1. Analyze (Analysis phase)

This stage is conducted to determine and understand the needs of learners regarding awareness of nutrition (needs assessment). This is accomplished through an investigative process and collecting information related to students' interest in learning and understanding nutrition information.

2. Design (Design phase)

In the Design stage, the conceptualization of the PBL-based e-module on the topic of work and energy integrated with nutrition, instruments for measuring students' awareness of nutrition, and lesson plans are prepared. The design of this e-module is purely conceptual, serving as the basis for the complete product design, which is depicted in a storyboard.

3. Develop (Development phase)

The Development stage involves the realization of the e-module product based on PBL, based on the design framework created in the Design phase. This makes the product ready for implementation. The e-module and instruments are validated by subject matter experts and media experts.

4. Implement (Implementation phase)

In the Implementation stage, the developed e-module is tested in schools as part of the research to assess its effectiveness and suitability. The research employs a quasi-experimental pretest-posttest control group design for field testing.

5. Evaluate (Evaluation phase)

The Evaluation stage is carried out to assess the suitability of the PBL-based e-module on the topic of work and energy integrated with nutrition for enhancing students' awareness of nutrition. The results of validation by experts and student response assessments after the completion of the learning activities are used as the basis for revising the e-module. This is done to refine the e-module and make it more suitable for student needs.

Before implementing the e-module with students, the e-module is first subjected to content and media validation. Content validation by experts is conducted to determine whether the content in the e-module aligns with the indicators of the research objectives. Validation is done using instruments provided to experts. Data from the validation by content and teaching experts are analyzed using a Likert scale, with scores ranging from 1-5, based on the attached

scoring guidelines, within the score range.

$$\text{Rentana skor} = \frac{\text{skor tertinggi} - \text{skor terendah}}{\text{jumlah pilihan jawaban}}$$

$$\text{Interpretasi skor (Is)} = \frac{\text{skor yang diobservasi}}{\text{skor yang diharapkan}}$$

There is a validation of the media expert based on ISO 9126. The validation process includes assessing functionality, reliability, usability, efficiency, and probability aspects. However, in this research, only functionality and usability aspects are considered. The validation results for the functionality aspect are measured using the Guttman Scale. This scale consists of "Success" and "Failure" responses with scores of 1 and 0. The level of validity for the functionality aspect of this software is calculated as follows:

$$\text{Presentase kevalidan (\%)} = \frac{\text{skor yang didapatkan}}{\text{skor maksimal}} \times 100$$

Table 1. Interpretation of Functionality Aspect Validity (Arikunto, 2012)

Percentage	Intepretation
0%-20%	Very Invalid
21%-40%	Invalid
41%-60%	Fairly Valid
61%-80%	Valid
81%-100%	Very Valid

As for the Usability aspect, it will be presented by calculating using the calculation below:

$$\text{Rentang skor} = \frac{\text{skor tertinggi} - \text{skor terendah}}{\text{jumlah pilihan jawaban}}$$

$$\text{Interpretasi skor (Is)} = \frac{\text{skor yang diobservasi}}{\text{skor yang diharapkan}}$$

Table 2. Validation Index (Riyanto & Hatmawan, 2020)

Validation Index	Interpretation
1,00 ≤ Is < 1,80	Very Invalid
1,80 ≤ Is < 2,60	Invalid
2,60 ≤ Is < 3,40	Fairly Valid
3,40 ≤ Is < 4,20	Valid
4,20 ≤ Is < 5,00	Very Valid

To measure the improvement in students' cognitive learning outcomes in the material of work and energy integrated with nutrition, the N-gain formula is used, as shown in the equation below.

$$\langle g \rangle = \frac{(\% \text{ rerata}_{\text{posttest}} - \% \text{ rerata}_{\text{pretest}})}{100 - \% \text{ rerata}_{\text{pretest}}}$$

Keterangan:

$\text{rerata}_{\text{posttest}}$: Average post-test score

$\text{rerata}_{\text{pretest}}$: Average pre-test score

As for the categories for N-gain improvement, they are:

Table 3. N-gain Value Categories (Hake, 1998)

Classification	Category
$\langle g \rangle \geq 0,7$	High
$0,7 > \langle g \rangle \geq 0,3$	Moderate
$\langle g \rangle < 0,3$	Low

The use of a PBL-based e-module in the material of work and energy integrated with nutrition is expected to not only improve the cognitive learning outcomes of X-grade students but also serve as a means to raise students' awareness of the importance of nutrition. To assess the increase in student awareness, observations and questionnaires are conducted and then calculated using a Likert scale.

Table 4. Likert Scale

Score	Category
4	Very Improved
3	Improved
2	Slightly Improved
1	Not Improved

By using the following calculation formula:

Table 5. Table of Suitability Categories

Average Score	Category
$3.35 < \bar{X} \leq 4.00$	Very Improved
$2.50 < \bar{X} \leq 3.25$	Improved
$1.75 < \bar{X} \leq 2.50$	Slightly Improved
$1.00 < \bar{X} \leq 1.75$	Not Improved

To determine whether the e-module is fully utilized in teaching, an implementation test of the e-module is conducted using an e-module implementation analysis based on the lesson plan. It is observed by an observer, and the average score is analyzed to determine the assessment results. The criteria for each stage of the teaching process are either achieved (terlaksana) or not achieved (tidak terlaksana). As for the assessment aspect of the lesson

that is achieved, it is given a score of 1, while not achieved is given a score of 0. The calculation of the implementation percentage is done for each assessment item using the following formula;:

$$P = \frac{\sum p}{n} \times 100\%$$

Keterangan:

P	is the percentage of lesson implementation
$\sum p$	is the total score of lesson implementation
n	is the number of assessed learning components

With this e-module, it is expected to encourage students to think critically.

Towards the issues presented and to understand the importance of nutrition, which is closely related to health and learning activities. Based on research conducted by Abduh (Abduh et al., 2020), it states that health is important and influences the education of students, especially their learning outcomes. Physical fitness plays a significant role in determining the learning conditions and learning outcomes of students (Gil-Espinosa et al., 2020).

1. Validation Results of the E-Module

The expected outcome of this study is the impact of using the PBL-based e-module on students' cognitive learning outcomes. Based on the validation calculations by media experts, a score of 87.5% was obtained, which falls into the category of very valid, indicating that the media is suitable for use. Similarly, based on the evaluation by subject matter experts, a score of 91.25% was obtained, which also falls into the category of very valid, signifying that the media is highly suitable for use.

Regarding the validation, reliability, difficulty level, and discrimination ability results for the 15 questions tested, you can refer to the table below:

Tabel 6. Uji validitas, reabilitas, tingkat kesukaran dan daya pembeda soal uji coba

Validitas	Daya Pembeda		Tingkat Kesukaran		Reliabilitas	
Valid	15	Baik	1	Mudah	11	Dipakai
Tidak Valid	0	Cukup	12	Sedang	4	Dibuang
		Jelek	2			

2. Improvement in Students' Cognitive Learning Outcomes

The students' learning outcomes examined in this study consist of pre-test and post-test scores and the achievement of learning outcomes. The minimum passing criteria (KKM) for Class X Science is 75. Here are the learning outcomes of the students after using the e-module.

Tabel 8. Besar Peningkatan dan N-Gain

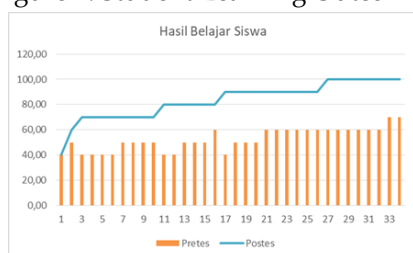
Nilai Rata-Rata		Peningkatan	N-Gain	Nilai tertinggi		Nilai Terendah	
Pretes	Postes			Pretes	Postes	Pretes	Postes
52,65	83,53	30,88	0,7	70	100	40	40

Based on the table above, the average score of students before using the PBL-based e-module is 52.65, and after using the PBL-based e-module, it is 83.53. The results show an increase of 30.88 between the Pretest and Posttest scores. According to the N-Gain analysis, the students' learning outcomes have an N-Gain value of 0.7, which falls into the moderate category. This means that using the PBL-based e-module is capable of improving students' learning outcomes in the material of work and energy integrated with nutrition. These student learning outcomes are used to assess the effectiveness of using the e-module for the material of work and energy integrated with nutrition.

The assessment of student learning outcomes aims to determine whether the learning activities have been effective. The effectiveness of students can be observed in their ability to achieve the predetermined learning objectives. The Pretest is given to assess the students' initial grasp of concepts before they receive the treatment with the e-module, while the Posttest is given to assess their grasp of concepts after receiving the treatment, which involves learning with the e-module.

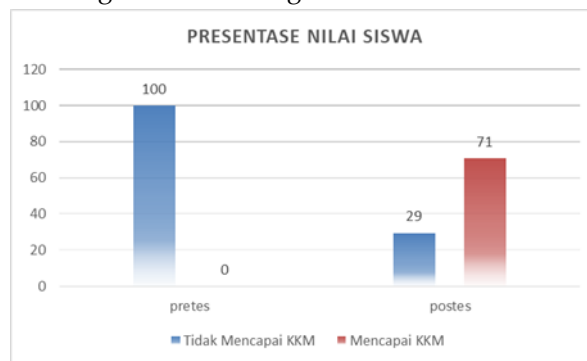
Based on the analysis of achieving the KKM (minimum passing criteria), no students achieved KKM scores during the Pretest. However, during the Posttest, 24 students achieved scores meeting the KKM, while 10 students scored below the KKM. The distribution of scores among students who met and did not meet the KKM can be seen in the following table:

Figure 2. Student Learning Outcomes



As for the students' learning outcomes, when presented in the form of a percentage based on the achievement of the minimum passing criteria (KKM), it can be observed in the following chart.

Figure 3. Percentage of Student Grades



From the chart above, there is a significant increase in the number of students who achieved the KKM between the Pretest and Posttest. This is because the e-module is designed with an attractive interface, accessible through smartphones, and includes images, music, and videos to facilitate students' understanding of the material. The combination of visual motion, sound, and video can enhance the appeal and facilitate the comprehension of information for students (Fitrianingsih & Musdalifah, 2015). Furthermore, the use of the problem-based learning method in the e-module aligns with the characteristics of the material on work and energy integrated with nutrition, thus assisting students in problem-solving processes.

CONCLUSION

Conclusion

Based on the research conducted, it can be interpreted that "There is an improvement in students' learning outcomes before and after using the e-module." This improvement indicates that the use of the e-module is effective in enhancing students' understanding of the learning material being studied. The e-module is considered suitable for use as a learning tool.

Recommendations

The school can collaborate with other institutions to provide regular nutritional counseling, and teachers from other subjects can participate in developing educational materials by integrating nutrition into their curriculum.

The government should make serious and continuous efforts to address adolescent nutrition issues by coordinating various agencies to comprehensively address nutritional problems.

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