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# Implementation of e-Learning Module Based on Science Technology Engineering Mathematics on Solar Cells Topic

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***ABSTRACT***
*This study was conducted to test the validity, practicality and effectiveness of implementing STEM-based e-learning modules on the topic of solar cellss to be used as teaching materials for students. This research was conducted at the Unsyiah Physics Education Study Program. The research method used is the Quasi Experiment method, pretest-posttest control group design. The module validity data were analyzed using a validation sheet. The results showed that the STEM-based e-learning module was valid. The practicality of the module was analyzed using activity observation sheets and student response sheets. The results showed that the implementation of STEM-based e-learning modules was practical to increase student activity and received positive responses from students. The effectiveness of the module was analyzed using the Three Tier diagnostic test using the CRI index, comparing the pretest results with the posttest result, and tested for significance through the two-mean difference test using the independent sample t-test. The results showed that implementsi e-learning modules on topic STEM-based solar cellss are effective to reduce the level of misconceptions and may improve learning outcomes (N-gain) student.*

## INTRODUCTION

Mastery of technology is an important thing that must be mastered in the current 4.0 millennial era. The framework in the millennial era is life and career, learning and innovation, as well as information, media and technology. Along with the increasingly rapid development of Technology and Information (IT), the need for an e-learning- based educational concept and mechanism has an effect on the transformation of conventional education into digital form so that IT is very influential in the teaching and learning process [1]. Information technology is often used as a means or tool in conveying learning activities. One of the applications of information technology in learning activities is an electronic module (e-module) which is a learning tool that contains materials, methods, limitations and ways of evaluating which are designed systematically and attractively to achieve the expected competencies [2] The development of information media nowadays is starting to experience

a transition from print media to digital media. Various digital media innovations are emerging today to make learning more meaningful. Sstate that e-learning provides great benefits for individuals around the world, from formal education facilities to training individuals in different topic [3].

Industrial engineering and science is a vital source of economic growth in developed countries, so that a substantial increase in interest and investment in Science, Technology, Engineering, and Mathematic s (STEM) [4]. Along with the development of sophisticated information technology accompanied by the STEM approach, each individual is able to make good use of existing technology. One alternative science learning that can build a generation capable of facing a challenging 21st century is STEM [5]. STEM is an approach to teaching and learning that integrates concepts, skills in science, technology, engineering and mathematics [6]. The United States of America is the first pioneer in the development of STEM education and has become a trend in the world of education today, so that various developed and developing countries have begun to adapt STEM in the school learning curriculum and lecture curriculum at universities. Stated that there are several benefits with the implementation STEM approach make students able to solve the problem for the better [7] [8], innovators, investors , independent [9] , logical thinkers, and technological literacy [10]. The characteristics of STEM learning include technology-based, Project Based Learning (PjBL), Problem Based Learning (PBL) [11], or Discovery Learning [12]. Some of these studies have integrated STEM into learning but none have integrated STEM into e-learning learning or information technology assistance. Researchers designed learning in classrooms and still used conventional learning systems.

The e-learning and STEM modules have advantages and disadvantages that complement each other: 1) In e-learning students understand the concept through the development of communication using electronic media and networks; 2) In STEM learning there is an engineering design process that makes students produce their best products. STEM enables students to learn academic concepts appropriately by applying 4 disciplines (science, technology, engineering and mathematics) [13] [14]. A more comprehensive way to implement the four disciplines with a way to teach it as a subject integrated. Science (S) and mathematics (M) are deemed appropriate to become facilitators of STEM education. STEM-based learning research that has been carried out includes the development of teaching materials [15] [16], the Physics module [17], module development [18], the use of Web-Educative, Chemistry, learning media [13]. Whereas research related to E-learning studied includes improving the quality of learning [19], improving learning outcomes [20], effectiveness as a learning medium, designing and implementing e- learning.

The concepts of physics have been studied since elementary school and various applications in everyday life, however, misconceptions (misconceptions) still occur in students' understanding. Misconception is the difference or incompatibility of a concept that is understood by someone with the actual concept [21]. Misconception research has been widely applied in various studies, including the effect of the STEM approach [22] [23], investigation of the level of misconceptions [24], identification of misconceptions using the CRI method [21], analysis of misconceptions in solving PISA standard math problems using CRI [25].

Based on some of the previous research has been widely using STEM-based modules, but is not yet integrated with e-learning, application of STEM-based learning modules through e- learning is considered very effective for learning material can be presented through software planted in e-learning as well as links to websites that can be visited by students anytime, anywhere, according to their individual wishes, the researcher wants to implement e-learning modules based on Science (S), Technology (T), Engineering (E), and Mathematic s (M) to be used in lectures and the topic Solar cells are one of the topic in modern physics courses suitable for developing STEM modules. The purpose of this study was to determine the validity and practicality of e-learning module based of STEM on the topic of solar cells to be used as student teaching materials, and to determine the effectiveness of e-learning module based of STEM on the topic of solar cells developed to support lectures.

## METHOD

This research consist of two stage, the first stage is Research and Development (R&D) and second stage is the implementation of product was conducted using a quasi-experimental research method. The procedure in this study was designed with a pretest-posttest control group design with a module development validation test stage (expert review) and an individual test (one to one). The instruments that must be prepared consist of a Semester Learning Plan (RPS), e-Modules, test questions, module validation sheets, lecture activity sheets and student response sheets.

The population contained in this study were students of the 4th semester of the Unsyiah physics education study program in the even semester of the 2019/2020 school year. The 4th semester students consist of two classes, with a total of 52 students. The sample selection in this study using the purposive sampling technique. This technique is determined based on the completeness of adequate and supportive facilities and infrastructure as well as the appropriate department for the application of the STEM approach, then comparing to choosing a class that takes modern physics courses guided by the caretaker lecturer. So the research sample was taken was the 4th-semester students of physics education study program which consisted of two classes, with a total of 52 students, class 01 (regular A) as the control class and class 02 (regular B) as the experimental class. The number of students in class 01 is 26 people, and the number of students in class 02 is 26 people.

*Lecture Module Development*

Lecture modules are teaching materials that are arranged systematically in language that is easily understood by students, so that students can learn independently and are able to relate to everyday life phenomena. This is because this lecture module is a STEM - based *e-learning* module . The design of this *e-learning* module aims to facilitate students in lectures. This module has been validated by material experts who aim to determine the feasibility of the module. This STEM - based *e-learning* module will be validated by two validators, dependent validator is Dr. Evendi, M.Pd and independent validator is Dr. Mursal, M.Si.

*Development of Diagnostic Test Questions to Reduce Misconceptions*

Misconceptions in this study are in the form of diagnostic test questions that aim to reduce misconceptions in students. In addition, the completeness of this question consists of multiple choice questions, then the CRI and the existence of a reasoned answer. The problem of this misconception has been determined using an analysis of the test questions which have determined the level of validity, reliability, difficulty level and differentiation power so that the test questions will be developed using the *Three Tier* diagnostic test questions. 15 questions of this misconception are used, then the questions will be developed into three levels (there is a reason and CRI index). Then from the 15 questions that have been developed, it will be validated by the validator to see that the questions are valid, quite valid, not valid or not valid. After the question was validated, research was carried out on physics students. This aims to find out which questions can be used as questions to see misconceptions in students.

*Analysis of the Validity of the e-Learning Module*

The validation sheet is used to measure the validity of the *e-learning* module. This research questionnaire will be addressed to expert lecturers. This questionnaire determines whether the teaching material is suitable for use without revision, with revision or not suitable for production. This questionnaire is in the form of a *rating-score* (graded scale) with 5 categories of assessment, namely Very Valid (4), Valid (3), Less Valid (2), and Invalid (1). The validity data obtained is in the form of statements from experts stating that the theoretical late module can be implemented in the lecture process. The criteria for determining the level of validity of the e-learning module are based on Table 1.

**Table 1.** Evaluation Criteria for the Level of Validation of the e-Learning Module

| Score Interval Assessment | Category Assessment | Information |
|---|---|---|
| 3.25 <Score <4.00 | Very Valid | Can be used without revision |
| 2.50 <Score ≤ 3.25 | Valid | Can be used with minor revisions |
| 1.75 <Score ≤ 2.50 | Less Valid | Can be used with multiple revisions |
| 1.00 <Score ≤ 1.75 | Invalid | Not yet usable and still requires consultation |

The analysis formula to measure the reliability of the validation results of the *e-learning* module that has been developed is analyzed descriptively qualitatively using statistical analysis *Percentage of Agreement* :

$$R = \left[1 - \frac{A - B}{A + B}\right] \times 100\ \% \quad (1)$$

Information:
$R$ = Observation sheet reliability coefficient
$A$ = The highest score of the two observers
$B$ = The lowest score of the two observers

The observation sheet instrument is said to be reliable if it has a reliability coefficient (R)> 75% [26].

Activity observation sheets in lectures when using STEM - based *e-learning* modules *are* used to determine student activity in lectures conducted by researchers, to find out how much interest students are in lectures conducted by researchers. Sheets observations and sheets . Student responses in lectures when using e-learning module based of STEMwere analyzed using percentage descriptive statistics .

Data misconceptions analyzed through the results of the answers and CRI students can distinguish between students who have a concept of right / *Knowledge of Correct Concept* (KCC), not sure / *No Confident* (NC), one of the concept / *Misconseption* (MIS), guess lucky / *Lucky Guess* (LG ), and lack of understanding / *Lack Knowledge* (LK). Each item was analyzed using a *Three-Tier Test* matrix . After knowing the distribution of student conceptions according to the CRI scale, the next stage can be identified the modified CRI term for each answer on the *Three-Tier Test* matrix . After the data is obtained, it is analyzed using a percentage to see the difference between students who have misconceptions through, 1) Selecting the type of identification; 2) Type identification poi n reduction in misconceptions.

Analysis of the initial ability of student learning outcomes can be tabulated based on the results of the *pretest* and *posttest* scores . The data on learning outcomes that have been recapitulated, the next step is to test the difference between two means, namely the t-test. The type of t-test used was *independent sample t-test.* Before carrying out the t-test, the analysis prerequisite test was carried out. The prerequisite analysis test (significance test) was in the form of a normality test and a homogeneity test of the data to test the significance of differences in the improvement of the conceptual mastery of the experimental class and control class.

## RESULTS AND DISCUSSIONS

This research will produce an *e-learning* module based on STEM in modern physics courses, the quality of this module will be measured through the Nieveen learning stage. Nieveen (1999: 94) states that there are three aspects that need to be considered in assessing the quality of a product, namely aspects of validity (*validity*), aspects of practicality (*practicality*), and aspects of effectiveness (*effectiveness*).

Lecture modules based on STEM are designed based on the results of the researchers' thoughts according to the lecture module developed by one of the Lecturers who teaches the Modern Physics course, about *e-learning* modules based on Multiple Representations on solar cells material. In order for this STEM-based lecture module to be feasible, the module can be validated using a module assessment instrument in the form of a validation sheet according to media experts and material experts. The results of the lecture module validation analysis according to the media validator are presented in Figure 1.

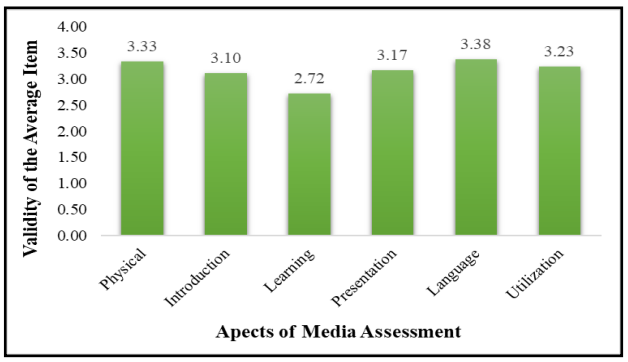


***Fig 1.*** *Results of Module Validation Analysis According to Media Experts*

Indicators of the validity of the *e-learning* module according to media experts are measured from the validity and reliability of the media assessment aspects, namely physical aspects, preliminary aspects, learning aspects, presentation aspects, language aspects, and utilization aspects. Based on Figure 1 above shows that the average score of validity of media assessment items on the physical aspect is 3.33 with very valid validity criteria, the preliminary aspect is 3.10 with valid validity criteria, the learning aspect is 2.72 with valid validity criteria, the presentation aspect is 3.17 with valid validity criteria, the language aspect is 3.38 with very valid validity criteria, and in the utilization aspect, it is 3.23 with valid validity criteria. The highest average value of validity is in the physical aspect and the lowest average value of validity is in the learning aspect. The data were analyzed by adding up the scores of each validator indicator by each validator and then averaging them for each aspect of the media assessment.

The results of the lecture module validation analysis according to the material validator are presented in Figure 2.

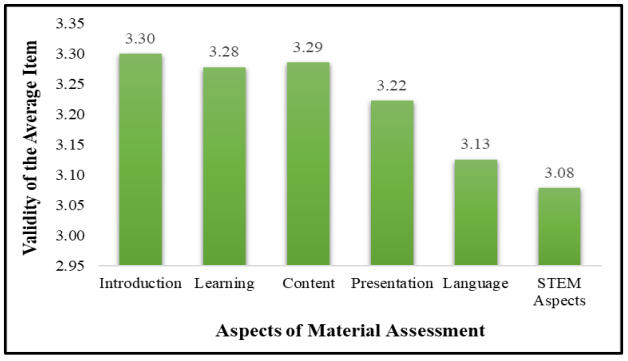


***Fig 2.*** *Results of Module Validation Analysis According to Material Experts*

Indicators of the validity of the *e-learning* module according to material experts are measured from the validity and reliability of the media assessment aspects, namely the preliminary aspects, the learning aspects, the content aspects, the presentation aspects, the language aspects, and the STEM aspects. Based on Figure 2 above shows that the average score of the validity of the material assessment items in the preliminary aspect is 3.30 with very valid validity criteria, the learning aspect

is 3.28 with very valid validity criteria, the content aspect is 3.29 with validity criteria very valid, in the presentation aspect of 3.22 with valid validity criteria, in the language aspect of 3.13 with validity criteria, and in the STEM aspect of 3.08 with valid validity criteria. The highest average value of validity is in the preliminary aspect and the lowest average value of validity is in the STEM aspect. Data were analyzed by adding up the scores for each validity indicator by each validator and then averaged for each aspect of the material assessment.

The results of this analysis are also supported by research which states that the validity of *e-learning* media is very valid in material aspects and media aspects. The indicator of a module is said to be valid if the validation value according to experts and theories meets the validity criteria with the category of assessment valid or very valid [11] [27].

Student activities at the time of the lecture process using STEM - based *e-learning* modules were observed by three observers. Observation activities in lectures for these two classes can be seen in Table 2 below.

**Table 2.** Results of Observation of Student Activities during Lectures

| No. | What is observed | Experiment Class | | Control Class | |
|---|---|---|---|---|---|
| | | Average | Category | Average | Category |
| 1 | Ask and collect inform ation | 3.67 | VG | 2.80 | G |
| 2 | Observe and associate | 2.27 | G | 1.60 | GE |
| 3 | Communicate and evaluate | 3.00 | G | 2.25 | G |

Information: VG = Very Good; G = Good, GE = Good Enough

The results of observing activities in lectures using e-learning module based of STEMwere analyzed using percentage descriptive statistics. In the aspect of asking and collecting information it has a percentage difference of 0.87 %, in the aspect of observing and associating it has a percentage difference of 0.67%, while in the aspect of communicating and evaluating it has a percentage difference of 0.75%, it can be concluded that with the development of the *e-learning* module STEM based can increase student learning activities on the topic of solar cellss.

This student response data is known after the lecture activity ends by filling out an online questionnaire in the experimental class where e-learning module based of STEM is applied. Student responses to e-learning module based of STEMare presented in Figure 3 below.

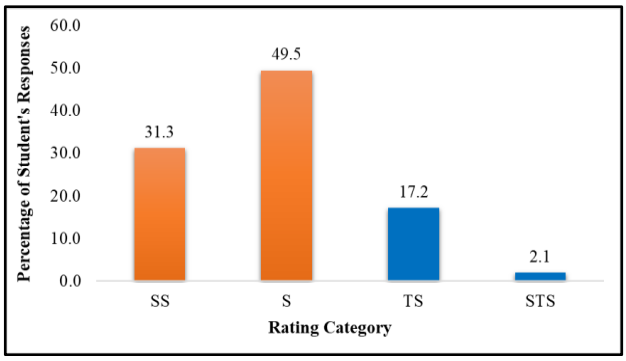


***Fig 3.*** *Student Responses to STEM-Based e-learning Modules*

In Figure 3 shows that the average student response to the module *e-learning* -based STEM by 31 , 3 % said Strongly Agree (SA), 49.5% stated Agree (A), 17.2% stated Disagree (D), and 2.1% stated Strongly Disagree (SD). This shows that students really understand the form of the statement presented by the researcher in the questionnaire. Thus, this STEM - based *e-learning* module received a positive response. This is supported by research which states that students's responses to the STEM

module are very good [28]. Almost all students gave positive responses and felt happy about STEM learning [35].

*Results of Analysis of the effectiveness of the e-Learning Module*

The instrument used to measure the misconceptions that occur in physics students in the control class and in the experimental class is through diagnostic test questions . Testing misconceptions in this study used diagnostic test questions that have been developed by the researcher totaling 15 multiple choice questions using reasoned answers and the presence of CRI, so to measure the misconceptions using *Three Tier* analysis . The reduction of misconceptions on the topic of solar cellss in the control class was analyzed using a three- *tier test* [24]. The results of data analysis on student misconceptions on cells topic can be seen in the following Table 3.

This proves that before implementing e-learning module based of STEMin the experimental class, the average student still has high misconceptions, then after applying e-learning module based of STEMthere is a reduction in misconceptions in these students [25]. The percentage results obtained after implementing *e-learning* module based of STEM in the experimental class were 11.79 % and this proves that student misconceptions have decreased [25]. The results of the overall data analysis show that after implementing lectures using e-learning module based of STEM it can reduce student misconceptions on the topic of solar cellss. The STEM approach has an effect on reducing student misconceptions [22], there is an effect of the STEM approach on learning physics and there is a decrease in misconceptions per sub-physics learning material [23].

**Table 3.** Results of Student Misconception Data Analysis on Solar Cellss Topic

| | | | | | | |
|---|---|---|---|---|---|---|
| Control | ΔM | 20.7 % | | Experimen | ΔM | 38.5% |
| | CRI Pretest | KCC = 20.26%<br>NC = 13.85%<br>MIS = 37.44%<br>LG = 7.18%<br>LK = 21.28% | | | CRI Pretest | KCC = 29.23%<br>NC = 12.31%<br>MIS = 32.31%<br>LG = 7.18%<br>LK = 18.97% |
| | CRI Posttest | KCC = 54.10%<br>NC = 13.08%<br>MIS = 26.67%<br>LG = 3.59%<br>LK = 2.56% | | | CRI Posttest | KCC = 61.28%<br>NC = 8.97%<br>MIS = 11.79%<br>LG = 3.85%<br>LK = 2.56% |

The cognitive improvement in student learning outcomes is presented in Figure 4 below.

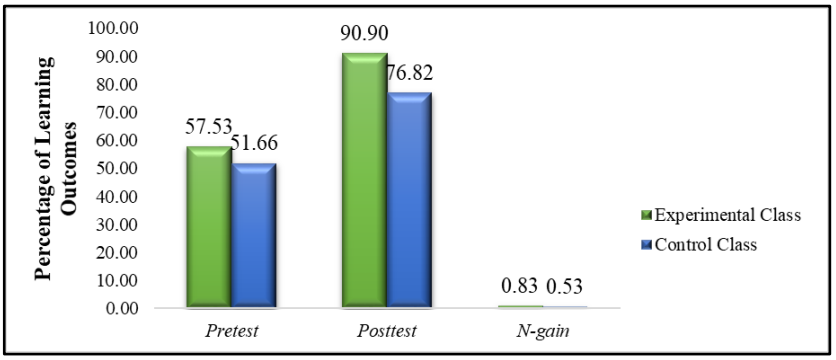


***Fig 4.*** *Analysis of Improving Student Learning Outcomes*

Based on Figure 4, it shows that the results of the previous data analysis concluded that lectures using e-learning module based of STEM were better than using ordinary e-learning modules. The results obtained in the experimental class obtained a pretest of 57.53 and a posttest of 90.90. Next in the control class the pretest was 51.66 and the posttest was 76.82. While the value of N-

gain obtained in the experimental class are 0 , 83 with high criteria and the control class that is 0.53 with the criteria being. So it can be stated that lectures in the experimental class are more effective than the control class. This is supported by various studies that state e-learning can improve the quality of learning [19], improve learning outcomes [20], and effective e-learning as a learning medium [21].

The data normality test is one of the analysis prerequisite tests which aims to determine the normality of the data from each class in this study whether the sample is normally distributed or not. In summary, it can be seen in Table 4 below.

**Table 4.** Summary of Data Normality Test pretest and posttest

| Class | Pretest Value | | Posttest Value | | Information |
|---|---|---|---|---|---|
| | $x^2_{count}$ | $x^2_{table}$ | $x^2_{count}$ | $x^2_{table}$ | |
| Experiment | 4.86 | 37.65 | 3.74 | 37.65 | Normally Distributed |
| Control | 2.66 | 37.65 | 5.48 | 37.65 | Normally Distributed |

The homogenity test function of variance is to find out whether this sample is successful from a population with the same variance (homogeneous) or unequal (heterogeneous), so that the results of this study apply to the population. The results of the data analysis can be briefly seen in Table 5.

**Table 5.** Summary of Data Homogeneity Test pretest and posttest

| Variance | $F_{count}$ | $F_{table}$ | Information |
|---|---|---|---|
| Pretest | 1.50 | 1.96 | Homogeneous |
| Posttest | 1.04 | 1.96 | Homogeneous |

The t test is used to determine whether there is a difference in the mean of the two unpaired samples. The main requirement in the t test or independent *sample t test* is that the data is normally distributed and homogeneous. The results of the *pretest* data analysis can be seen in Table 6 below.

**Table 6.** Recapitulation of the pretest t-test for the experimental class and control class

| Group | Average | $t_{count}$ | $t_{table}$ | Interpretation | Conclusion |
|---|---|---|---|---|---|
| Experiment | 57.53 | 1.27 | 1.68 | tcount < ttable | Significant |
| Control | 51.66 | | | | |

Table 6 shows that the *pretest* value for the experimental class and control class obtained a t value of 1.27. According to [29], if the $t_{count}$ value is smaller than the $t_{table}$, then there is no significant difference between the two classes. This statement can be concluded that before being treated, the conditions for the two classes were the same. This means that there is no difference in student learning outcomes in the two classes. While the results of the *posttest* data analysis can be seen in Table 7.

**Table 7.** Posttest t-test recapitulation for the experimental class and control class

| Group | Average | $t_{count}$ | $t_{table}$ | Interpretation | Conclusion |
|---|---|---|---|---|---|
| Experiment | 90.90 | 5.35 | 1.68 | tcount < ttable | Significant |
| Control | 76.82 | | | | |

Based on Table 7, it is found that the value of $t_{count} < t_{table}$ is 5.35 >1.68, it can be concluded that there is a difference in the average student learning outcomes between lectures by implementing e-learning module based of STEMand the *e-learning* module . This proves that the application or implementation of e-learning module based of STEM in the experimental class is more effective than lectures with the control class *e-learning* module. This is supported by the results of research which states that the modules developed are effective in improving students' creative thinking skills compared to the usual teaching materials used in schools, because learning activities use modules that contain problem-based learning syntax, which triggers students practice their skills to improve creative thinking [30]. E-*learning* can be used to improve understanding of the material and expand the

resources of teaching materials as well as increase learning activities and assist teachers in efficient learning time in the classroom. Iintegrated learning in the STEM field has a positive influence on student learning achievement [17].

## CONCLUSION AND SUGGESTION

Based on the results of research that has been carried out on the implementation of e-learning module based of STEM at the Unsyiah Physics Education Study Program, it can be concluded that : 1) The validity of e-learning module based of STEMon the topic of Solar Cellss in terms of aspects of media assessment by experts is valid with The average value is 3.17 and the aspect of material assessment by experts is very valid with an average value of 3.22, so that e-learning module based of STEMis suitable for use as student teaching materials ; 2) Implementation of e-learning module based of STEM on the topic of practical Solar Cellss to increase student activity and get a positive response from students, so that STEM - based *e-learning* modules can be used as teaching materials in physics lectures ; 3) The implementation of e-learning module based of STEM on the topic of Solar Cellss is effective in reducing the level of misconceptions by 38.5% and increasing learning outcomes ( *N-gain* ) by 0.83, so that e-learning module based of STEMon the topic of Solar Cellss is effectively used as teaching material among students of the Unsyiah Physics Education Study Program.

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