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The Implementation of the Dilemma-STEAM Model in Fluid Dynamics Subjects through the Archimedes Screw Project

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Abstract

Physics is one of the sciences that is closely related to daily life, one example being fluid material material. However, the understanding of physics, especially fluid material, is still relatively low. These problems can be overcome by applying a learning model that is integrated with teaching materials that have developed over time. The dilemma STEAM learning model is a learning model that can help students to understand physics based on students' experiences. The dilemma STEAM learning model has five learning stages that can make learners recognize the problem, find solutions, and then solve the problem. This study aims to develop teaching materials based on the dynamic dilemma STEAM learning model based on the dilemma STEAM learning model. The development of the Archimedes Screw Project equipped with E-Modules as teaching materials was developed using the ADDIE development model. The ADDIE development model has several stages, namely Analysis, Design, Development, Implementation, and Evaluation. E-Modules are made using the Canva application which can be accessed anywhere and anytime. After the E-Module was developed, the next stage was the feasibility test of the E-Module by experts. The results of the feasibility test by media experts obtained a result of 88.3% with a very feasible category. Meanwhile, the results of the feasibility test by material experts obtained a result of 84% with a very feasible category. And the results of the feasibility test by learning experts obtained a result of 83.3%. And the readability of the E-Modul by the student after using it is 72.4% with a good read, which is demonstrated by the success of the student assembling Archimedes Screw by following five stages of the dilemma STEAM learning model.

Keywords: archimedes screw, dilemma steam, dynamic fluid

INTRODUCTION

The dilemma story learning paradigm was first presented by Lawrence Kohlberg in 1984. This paradigm is a fundamental concept that connects ethical challenges (Taylor & Taylor, 2022), moral development (Faiz et al., 2022), and professional progress in diverse educational contexts (Bourke et al., 2021). The dilemma story fosters critical thinking (Wallis et al., 2021), problem-solving abilities, and the acquisition of ethical ideals by involving students in ethical challenges that pertain to real-life concerns, such as environmental problems (Rahmawati et al., 2022). Dilemma stories offer learners the chance to make choices and resolve the challenges they face (Macpherson et al., 2020). These

stories present real-life scenarios that prompt students to consider various perspectives and information sources, encouraging a broader perspective and independent decision-making skills (Bourke et al., 2021). Meanwhile, decision-making by learners can be incorporated into the learning process by providing a stimulus for them to describe their ideas (Perry-Hazan & Somech, 2021). Additionally, dilemma stories can be combined with other approaches to develop further skills (Natalya et al., 2021). According to Chong (2021), STEAM can be combined with dilemma stories. STEAM is able to provide solutions to the dilemmas presented by teachers in facing educational changes supported by technology (Ramey, 2023).

STEAM is a field that can develop critical thinking skills (Okolie et al., 2021). STEAM helps learners collect, analyze, and solve problems and can serve as a link between various issues (Quigley et al., 2020) because it integrates disciplines such as Science, Technology, Engineering, Arts, and Mathematics (Zhan et al., 2023). STEAM has the benefit of bringing together theory and practice, encompassing science, technology, art, and mathematics in a cohesive teaching and learning environment (Belbase et al., 2021). It provides a comprehensive strategy that combines multiple disciplines to improve learning outcomes (Zhang & Song, 2022). STEAM education is essential in high schools as it cultivates well-rounded individuals (Lin & Tsai, 2020) with inventive skills, enhances the quality of education, and improves teaching effectiveness (Zhan et al., 2023).

STEAM education not only enhances students' critical thinking, problem-solving, and collaboration skills (Fan et al., 2020) but also helps in increasing learning motivation (Conradty, 2020), developing life skills, communication abilities, teamwork, and planning capabilities (Li et al., 2022). By integrating dilemma stories into STEAM projects (Dao, 2022), students actively participate in real-world challenges (Jones, 2020), contemplate ethical principles (Rahmawati et al., 2022), devise remedies, track their progress, and assess the results, leading to a profound shift in their learning experiences (Rahmawati et al., 2023). This approach promotes deep comprehension while cultivating analytical reasoning, problem-solving abilities, and ecological consciousness among students, enabling them to effectively tackle sustainability challenges. It is crucial to pursue an educational methodology that can enhance students' comprehension of physics principles (Nainggolan, 2023; Speirs et al., 2023). This approach is called the Dilemma STEAM Approach.

The Dilemma-STEAM learning model is a cutting-edge method that combines dilemma stories with Science, Technology, Engineering, Arts, and Mathematics (STEAM) projects to enrich students' learning experiences and improve their educational outcomes. This learning model fosters student engagement in critical thinking, teamwork, and problem-solving abilities by tackling real-world challenges across multiple disciplines (Natalya et al., 2021). Dilemma-STEAM is an innovative teaching model that integrates dilemma stories. It consists of five stages of learning: reflection, exploration, elaboration, integration, and transformation (Rahmawati, 2023). According to Rahmawati (2020), the dilemma STEAM learning model can improve students' literacy. Additionally, research conducted by Rahmawati (2022) found that the dilemma STEAM learning model enhances the ability to think critically and reflect on social issues, fosters collaborative decision-making abilities, and raises awareness of the importance of environmental conservation to promote sustainable development. Based on the literature, the research discussed in this paper aims to integrate the Static Fluid E-Module with the Dilemma-STEAM learning model.

The study of dynamic fluid is a captivating discipline with direct applications to everyday life, making it an intriguing subject for students. Efficient pedagogical approaches for intricate concepts, such as fluid dynamics, involve employing group environments where practical implementations of fluid dynamics principles are utilized (Aliligay et al., 2022). According to the research by Priyadi et al. (2021), fluid dynamics is one of the physics topics that often leads to misconceptions in understanding the concept. This is supported by the results of a needs analysis, which found that 52% of students consider fluid dynamics easy to understand, while 48% find it difficult. Meanwhile, research conducted by Batlolona et al. (2023) found that students' understanding of fluid dynamics is still relatively low, with an average score of 63.45 on a scale of 0-100. This indicates that conceptual errors cause difficulties in learning physics. Through the implementation of experiential learning and the promotion of active engagement, educators can optimize learning outcomes and inspire students to comprehend complex principles such as fluid dynamics (Mandhana & Caruso, 2023). Therefore, it is necessary to

integrate project-assisted teaching materials with the dilemma STEAM learning model to help facilitate students' understanding.

METHODS

This research employed a Research and Development (R&D) method. The objective of this research is to develop an E-Module, using the approach of dilemma STEAM learning model. The ADDIE model was utilized as the research framework for product development. The model consists of five stages: analysis, design, development, implementation, and evaluation.

Analysis Stage

The first stage is the analysis stage. In the analysis stage, learning needs analysis and learner character analysis were conducted.

Design Stage

The second stage is the design stage. At this stage, the design process is carried out on the product to be made. in this case the product developed is an E-Module integrated with the Dilemma STEAM learning model. The Dilemma STEAM Learning Model contains 5 stages.

TABLE 1. Five Stages of Dilemma STEAM Learning Model

Stages	Implementation of Dilemma STEAM Learning Model
Reflections *Value Reflection*	• Provide a stimulus in the form of initial problems such as case studies in the form of photos, images, videos, etc. • Individually, learners reflect on the problems that have been given.
Exploration *Problem Solving and Decision Making*	At this stage, problem solving in case studies and then learners can make decisions on the problem.
Elaboration *Content Integration*	• Materials are provided in accordance with related issues and values to be developed. • Providing material can be focused so that it is not too much and is relevant to the problems and issues discussed.
Integration STEAM *Integration*	STEAM project development stage as a problem solving or solution. In the research conducted, the STEAM project used is Archimedes Screw.
Transformation *Transformation*	An assessment of learning related to the understanding of concepts and reflection on values. At this stage, it is no longer the cognitive level that is discussed, but about how students' experiences are nurtured through the stages of the dilemma STEAM learning model.

Development Stage

At the development stage, everything that has been prepared during the design stage can be realized. At this stage, electronic modules based on the learning model are also developed. After product development, the next step is to test the feasibility of the product to be developed. The product will be assessed by media experts, material experts, and learning experts. The structure and details of each instrument are displayed in TABLE 2, 3 and 4.

The instrument used to be an instrument for assessing the feasibility test by media experts, is an aspect that must be present in the E-Module so that the E-Module is considered a good E-Module. The following are the aspects needed to make e-modules categorized as good e-modules:

- Self Instructional, the use of e-modules must be able to make students do learning independently.
- Self Contained, the material contained in the e-module must contain all parts of one part of the competency or sub-competency as a whole. So that students or users can study the material thoroughly to master the material discussed.
- Stand Alone: E-The module used must stand alone, independent of other teaching materials or learning media.
- Adaptive, adaptive here is that e-modules must adjust the development of science and technology, so that they can be used flexibly.
- User Friendly, E-Module must be user friendly or friendly to its users, such as easy to use, easy to access, use of simple and easy to understand language, and easy to understand.

TABLE 2. Instrument Feasibility by Media experts

Aspect	Indicator
Self Instructional	1. The e-module has clear learning objectives 2. E-Modules are equipped with illustrations/news/video/pictures
Selft Contained	E-Modules contain all the material in accordance with the learning outcomes
Stand Alone	E-Modules are independent of other teaching materials
Adaptive	E-Modules adjust to the development of technology and science
User Friendly	1. E-Modules easily accessible anytime and anywhere 2. E-Module display can be customized with the device that accesses it

For the feasibility test assessment in terms of material, because the STEAM dilemma learning model itself is close to the daily lives and experiences of students, a context or content related to the daily lives of students is needed. In this case, because the project used is a project or implementation of the concept of dynamic fluid, the material compiled is fluid material with dynamic fluid sub-materials that must be arranged mathematically. Materials and sub-materials must be structured in accordance with the learning outcomes (Roblin et al., 2018).

TABLE 3. Intrument Feasibility by Material experts

Aspect	Indicator
Material	1. The material in the E-Module is in accordance with the learning outcomes learning outcomes/learning objectives that will be achieved by students 2. The material can be applied in life everyday life 3. Suitability of material with illustrations/pictures 4. The material is presented systematically and continuous 5. The material presented is in accordance with development of technology and science knowledge
Presentations	1. The use of language in the E-Module is easy to understand. 2. The language used is appropriate to the level of learners' level of understanding 3. The spelling used refers to General Guidelines for Indonesian Spelling (Pedoman Umum Ejaan Bahasa Indonesia) 4. The images/illustrations displayed are clear or not blurry

The data to be obtained in this research is quantitative data in the form of scores (numbers) The feasibility of the product will be analyzed descriptively. In this research, data analysis techniques will use the Likert Scale. The data obtained will be analyzed using a Likert scale. Likert scale is a scale that has four to five question items. Likert scales are discrete scales that consist of a limited number of pre-defined categories. They are commonly used in social sciences to assess different traits (Dombi and Jónás, 2020). Accurate Likert scales in research can offer data intervals by addressing certain needs such as the composite score, midpoint, and amount of points. This allows for the application of various statistical procedures based on the study aim (Tanujaya et al., 2022).

TABLE 4. Intrument Feasibility by Learning experts

Aspect	Indicator
Material	1. The material in the E-Module supports Learning 2. The material in the E-Module is in accordance with the learning outcomes/learning objectives that students will achieve. 3. E-Modules present real problems/facts related to the material
Learning Model	1. E-Modules contain learning stages learning stages that are in accordance with the learning model Dilemma STEAM 2. The E-Module contains the implementation of the Dilemma STEAM learning model 3. Video/Picture/Illustration Case closely related to daily life 4. E-Modules contain all components of STEAM
Presentation of Language	1. The language used in the E-Module easy to understand 2. The language used in the E-Module is communicative 3. The spelling used refers to General Guidelines for Indonesian Spelling (*Pedoman Umum Ejaan Bahasa Indonesia*)

TABLE 5. Likert Scale Description

Percentage	Description
81% $\leq \bar{x} \leq$ 100%	Very Feasible
61% $\leq \bar{x} \leq$ 80.5%	Feasible
41% $\leq \bar{x} \leq$ 60.5%	Feasible Enough
21% $\leq \bar{x} \leq$ 40.5%	Not Feasible
$\leq$ 20.5%	Very Not Feasible

The value to be obtained from each indicator, can be solved using the equation

$$\bar{x} = \frac{\sum score\ obtained}{\sum maximum\ score}\ x\ 100\ \% \quad (1)$$

Implementation Stage

During the implementation phase, the perceptions of ten high school students, who were part of a small group, were assessed.

TABLE 6. Instrument of students' perceptions before using e-modules

Questions
1. *I have an interest in learning dynamic fluid material*
2. *I have the motivation to learn dynamic fluid material*
3. *I find it easy to learn dynamic fluid material*
4. *I don't get bored quickly learning dynamic fluid material*
5. *I think that dynamic fluid material only contains difficult formulas*
6. *I know the application of dynamic fluid material in daily life*
7. *The material content on dynamic fluid teaching materials that I have used increases curiosity*
8. *The experiments and experiments presented in the dynamic fluid teaching materials that I have used can make me skillful in making decisions*
9. *The dynamic fluid teaching materials that I have used have presented the material contextually, namely by linking physics concepts to everyday life.*
10. *The dynamic fluid teaching materials that I have used have implemented technology into the learning stage.*

TABLE 7. Instrument of students' perceptions after using e-modules

Questions
1. *After using the E-Module, I have an interest in learning dynamic fluid material.*
2. *After using the E-Module, I have the motivation to learn dynamic fluid material.*
3. *After using the E-Module I find it easy to learn dynamic fluid material.*
4. *After using the E-Module, I don't get bored quickly learning dynamic fluid material.*
5. *After using the E-Module I easily understand dynamic fluid material*
6. *The e-module based on the dilemma STEAM learning model presents the material contextually by linking the concept of dynamic fluid to daily events, thus helping me understand the concept of dynamic fluid.*
7. *After using the E-Module, I know the application of dynamic fluid in daily life.*
8. *The dilemma STEAM-based dynamic fluid e-module presents a dilemma story that makes me interested in solving problems in the dilemma story presented and in everyday life.*
9. *The trials and experiments presented in the dynamic fluid teaching materials presented in the E-Module can make me skillful in decision making.*
10. *Dynamic fluid E-modules present illustrations/problems that are packaged through interesting manrik stories/news illustrations/video/pictures.*
11. *After using the E-Module, I can learn dynamic fluid material independently.*

Meanwhile, the results of student perceptions were measured for their interperence value to then determine the results of product readability by students in accordance with the following criteria.

TABLE 8. Interpretation of product readability level

Percentage	Description
$81\% \leq \bar{x} \leq 100\%$	Very Good
$61\% \leq \bar{x} \leq 80.5\%$	Good
$41\% \leq \bar{x} \leq 60.5\%$	Good enough
$21\% \leq \bar{x} \leq 40.5\%$	Bad
$\leq 20.5\%$	Very bad

The value to be obtained from each indicator, can be solved using the equation

$$\bar{x} = \frac{The\ total\ score\ obtained}{Score\ Maximum\ x\ Total\ number\ of\ questions} \times 100\ \% \quad (2)$$

Evaluation Stage

For the last stage, namely evaluation, basically at every stage of ADDIE that is carried out, the evaluation stage will apply.

RESULTS AND DISCUSSION

The teaching materials produced from this research are E-Modules based on the STEAM Dilemma Learning Model on Dynamic Fluid Material. The E-Module is made using Canva which can be accessed via the web or application. The E-Module is then exported into a link so that users do not need to download first if they want to use the E-Module. The E-Module is also equipped with images, news illustrations, and videos that can be accessed without the need for other teaching materials. E-Module Based on STEAM Dilemma Learning Model, there is one learning activity, whose activities are filled with five stages of the STEAM dilemma learning model. E-Module Based on STEAM Dilemma Learning Model is developed with physics material that is closely related to daily life, so that in its use, E-Modules can be studied independently by users. Dynamic fluid material also adapts the latest curriculum, namely the independent curriculum. This E-Module can be accessed via PC/Computer/Smartphone/Tablet as long as the user has an internet network. The following are the components of the STEAM Dilemma Learning Model Based E-Module:

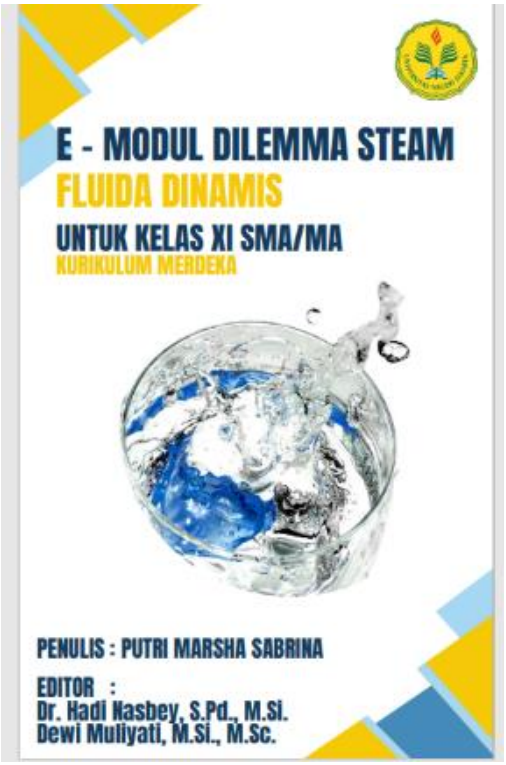

FIGURE 1. Cover of E-Module

FIGURE 2. Table of Contents

FIGURE 3. Instructions for use

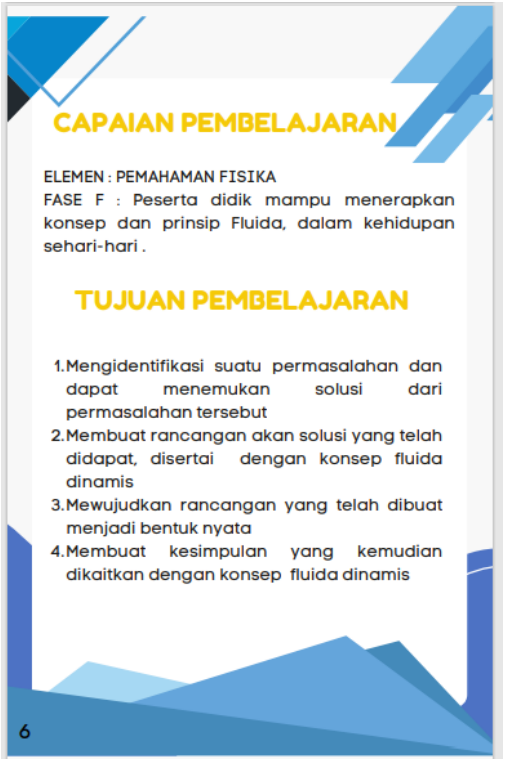

FIGURE 4. Learning Outcomes and Learning Objectives

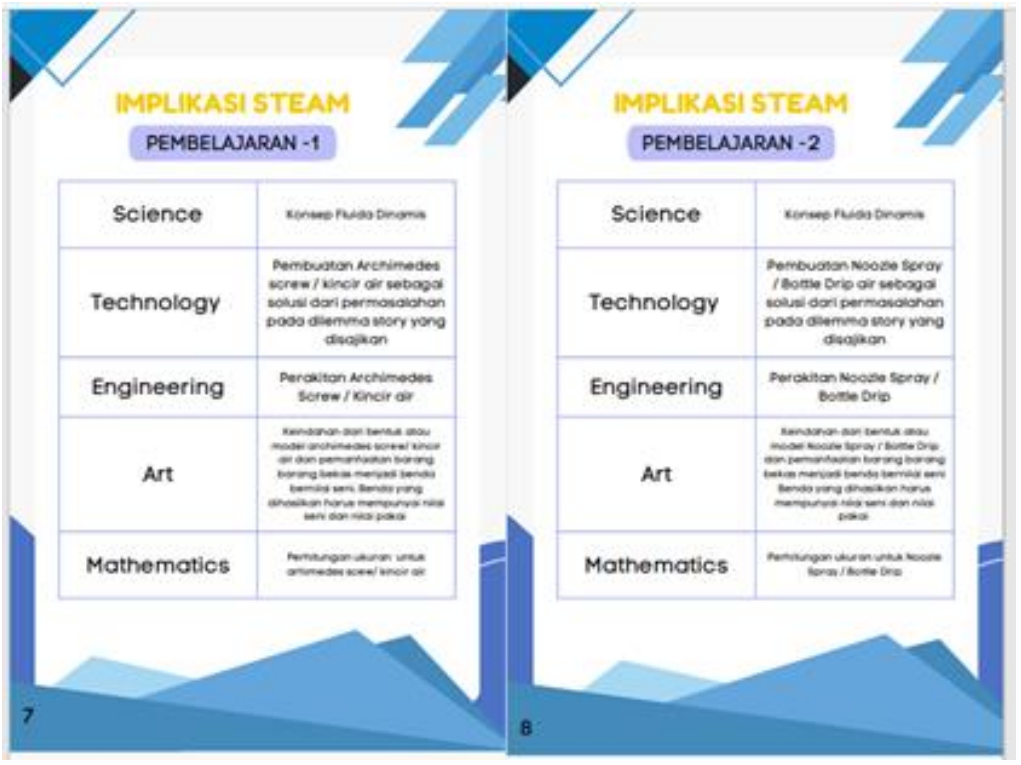

FIGURE 5. Implementation of STEAM

FIGURE 6. Project-based Learning Archimedes Screw Reflections Stage

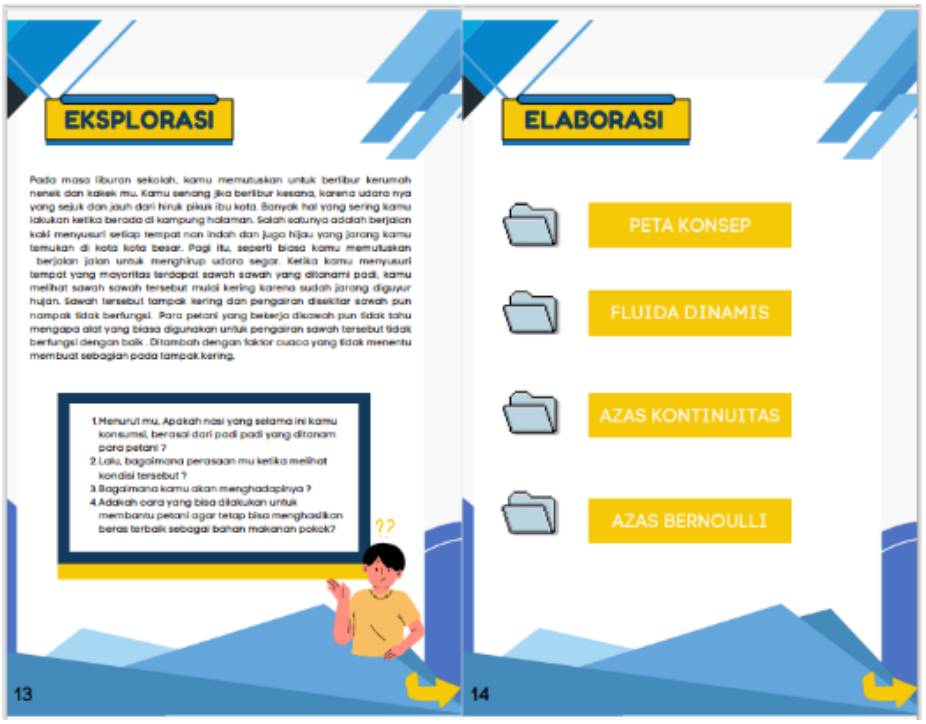

FIGURE 7. Project-based Learning Archimedes Screw Exploration and Elaboration Stage

FIGURE 8. Project-based Learning Archimedes Screw Integration and Transformation Stage

TABLE 9. Five Stages of Dilemma STEAM Learning Model

Stages	Implementation of Dilemma STEAM Learning Model
Reflections *Value Reflection*	Provide stimulation by discussing rice as a staple food for Indonesian people by comparing the quality of rice found in restaurants or restaurants.
Exploration *Problem Solving and Decision Making*	In the exploration part, a story sketch is given with the problem of farmers' fields that look dry without any water. At this stage, problem solving in case studies and then learners can make decisions on the problem.
Elaboration *Content Integration*	• Materials are provided in accordance with related issues and values to be developed. • Providing material can be focused so that it is not too much and is relevant to the problems and issues discussed. • The material discussed in this section is fluid material with the concept of dynamic fluid.
Integration STEAM *Integration*	STEAM project development stage as a problem solving or solution. In the research conducted, the STEAM project used is Archimedes Screw. An explanation of the implementation of STEAM in the Archimedes Screw project will be discussed in TABLE 10.
Transformation *Transformation*	An assessment of learning related to the understanding of concepts and reflection on values. At this stage, it is no longer the cognitive level that is discussed, but about how students' experiences are nurtured through the stages of the dilemma STEAM learning model.

TABLE 10. Implementation of STEAM in Project Archimedes Screw-based

Science	Dynamic Fluid Concepts
Technology	Making Archimedes crew as a solution to the problem in the dilemma story presented
Engineering	Archimedes Screw assembly
Art	The beauty of the archimedes screw shape or model and the utilization of used goods into objects of artistic value. Objects produced must have artistic value and use value.
Mathematics	Calculation of size for Archimedes Screw

After the E-Module product has passed the development , the next step is to test the feasibility of the product by experts. This product was tested for feasibility by material experts, media experts, and learning experts. The purpose of the feasibility test is to determine the feasibility of the product developed before it is tested on students. The product feasibility test is carried out by providing instruments and questionnaires to experts, to ultimately become material for improvement.

TABLE 11. Feasibility Test Results by Media Experts

Aspect	Percentage	Interpretation
Self Instructional	90%	Very Feasible
Selft Contained	100%	Very Feasible
Stand Alone	100%	Very Feasible
Adaptive	40%	Not Feasible
User Friendly	100%	Very Feasible
Presentation of Language	100%	Very Feasible
Average of all aspects	**83.3**	**Very Feasible**

The results of the product feasibility test by media experts, it can be concluded that the STEAM Dilemma Learning Model-Based E-Module is very feasible with a percentage of 88.3%. For the adaptive part of the feasibility test by media experts, it received a low score because the material used in the E-Module still adapted the material listed in the textbook and had not been able to explain well how the development of material in accordance with technological updates. For further research, the material used in the E-Module should be well packaged by providing examples through the most

updated problems and the material discussed may not be too much and full of theories such as in textbooks.

TABLE 12. Feasibility Test Results by Material experts

Aspect	Percentage	Interpretation
Material	76%	Feasible
Presentations	84%	Very Feasible
Average of all aspects	**84%**	**Very Feasible**

The results of the product feasibility test by material experts, it can be concluded that the STEAM Dilemma Learning Model-Based E-Module is very feasible with a percentage of 84%.

TABLE 13. Feasibility Test Results by Learning Experts

Aspect	Percentage	Interpretation
Material	83%	Very Feasible
Learning Model	90%	Very Feasible
Presentation of Language	77%	Very Feasible
Average of all aspects	**83.3%**	**Very Feasible**

The results of the product feasibility test by learning experts can be concluded that the STEAM Dilemma Learning Model-Based E-Module is very feasible with a percentage of 83.3%.

Before conducting the perception test, students start using the E-Module by going through step by step according to the stages in the dilemma STEAM learning model. In the perception test by learners, learners must use the E-Module in a structured way to carry out the five stages of the STEAM dilemma learning model. Learners are also asked to directly create projects as a solution to the problems discussed at the reflection stage. After using the E-Module, students are asked to give their perceptions of the e-module developed by filling out a questionnaire on Google Form.

FIGURE 9. Project Archimedes Screw Creation

TABLE 14. Student Perception Test Results Before Using E-Module

Questions	Total Amount
Question Number 1	33
Question Number 2	32
Question Number 3	26
Question Number 4	24
Question Number 5	31
Question Number 6	26
Question Number 7	31
Question Number 8	30
Question Number 9	31
Question Number 10	27
Total	320
Percentage	$\frac{293}{5\ x\ 10} x\ 100\% = 58.6\%$

TABLE 15. Student Perception Test Results After Using E-Module

Questions	Total Amount
Question Number 1	37
Question Number 2	37
Question Number 3	37
Question Number 4	37
Question Number 5	36
Question Number 6	36
Question Number 7	35
Question Number 8	35
Question Number 9	37
Question Number 10	35
Total	320
Percentage	$\frac{362}{5\ x\ 10} x\ 100\% = 72.4\%$

After conducting trials on students, the results obtained before students used the E-Modul were 58.6%. Then after using the E-Module, the results obtained were 72.4%. In these results, it is evident that students can read and implement the e-module well. learners can depart from the problems and issues discussed at the reflection and exploration stage. then before forming an archimedes screw, students first understand the example or illustration of making an archimedes screw to then be used as a tool for the solution of the problem. It can be argued that E-Modules can effectively assist in the learning process. From the results obtained from student preception after using the E-Module, it can be concluded that the dilemma STEAM Learning Model-Based E-Module on dynamic fluid material is well-read by students.

The results obtained from the implementation of the dilemma STEAM learning model with teaching materials equipped with Archimedes Screw making projects, can help students understand physics material, especially dynamic fluids. Through the dilemma story presented is able to help students understand and think critically about the problems given so that in the integration process which is integrated with the STEAM model, students can directly convey their understanding of the concepts or materials discussed by making projects presented through dilemma stories, students are able to modify with the understanding they understand. The dilemma STEAM learning model has limitations on the part of the story presented, the story presented must be packaged as interesting as possible by paying attention to current issues or problems so that it can increase the enthusiasm of students to learn a material through a story that raises a dilemma.

CONCLUSION

The dilemma STEAM learning model is able to improve problem solving skills and critical thinking skills of students because, physics itself does not only focus on formulas and numbers. Frequently, students are faced with problems related to the environment but students cannot immediately provide answers or solutions. But it turns out that when studied with the problems raised at the reflection stage, there are many problems that can be studied and found solutions through STEAM-based project projects which certainly help students in learning the concepts of physics concepts, especially dynamic fluids in everyday life. In completing calculations in physics, skills are needed that can be trained through the dilemma STEAM learning model that can be implemented with teaching materials. In the stages of the dilemma STEAM learning model, each stage is carried out by the learners themselves, from reflection to transformation. Learners are asked to reflect on the problem through the dilemma story presented and then find a solution by creating their own solutions or modifying existing solutions, so that the results of dilemma STEAM learning are no longer in the cognitive field but also in the student experience. This is certainly closely related to physics subjects that are not far from the experiences and problems found in the immediate environment of everyday students. The limitations in this research are: the problems or issues given as a stimulus are sometimes still not up to date for some students. for some students may feel less familiar with the problems or issues given. So that a more complete stimulus is needed to provide a brief review of students regarding the issues discussed.

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