

# Study of ISLE-BASED STEM Approaches and Models in Its Use for Teacher Professionalism Development in Geometric Optical Case Studies

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**Abstract:** 21st century learning emphasizes that information and knowledge are obtained together with good communication and cooperation among fellow students in building their knowledge. One of the appropriate learning models and approaches to be applied in accordance with 21st century learning is the Investigative Science Learning Environment (ISLE) combined with Science, Technology, Engineering and Mathematics (STEM). This study uses the Research and development (R & D) method with the ADDIE (Analysis-Design-Develop-Implement-Evaluate) model. The product developed in this study is ISLE-based STEM learning media in the form of Student Worksheets on Geometry Optics material and the relationship between ISLE-based STEM learning and Teacher Professionalism Development is reviewed.

**Keywords:** Student worksheets; ISLE based STEM; Teacher professionalism development; Geometric optics

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## Introduction

Indonesia is the largest archipelagic country, with a population of 250 million people, and has an obligation to produce quality human resources so that they can compete with other countries in the world. Increasing quality of Human Resources can be improved through improvements in the education sector (Fathoni et al., 2020).

Schools are required to be able to prepare students who can compete in the world of education by following the development of 21st century learning. Ramdani, et al (2019) argue that the importance of developing learning in the 21st century has been realized by educational actors. Developing LAB skills-based learning in recent years has become an interesting study for observers, researchers and educational actors.

Learning in the 21st century requires teachers to present collaborative learning in the learning process.

Permendikbud number 21 of 2016 states that there are 4C skills that must be present in the 2013 curriculum learning which is based on 21st century competencies. These 4C skills include Critical Thinking, Communication, Collaboration, and Creativity. In the development of 21st century learning, learning is more student-centred (student centered) teachers can act as facilitators, mediators, motivators, as well as leaders in the learning process, different from conventional learning where learning is teacher-centred.

A teacher must be able to become a role model for 21st century skills-based learning because a teacher is someone who is directly involved in the process of achieving educational goals (Makhrus et al., 2019). 21st century learning emphasizes that information and knowledge are obtained together with good communication and cooperation and demands that students be able to think critically in building their knowledge.

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An approach and learning model is needed that can build the ability to think critically and increase the mastery of collaboration because of the students being educated so that it becomes one of the alternatives for improving student learning outcomes. One of the appropriate approaches and models to be applied to physics learning in schools is the Investigative Science Learning Environment (ISLE) based on Science, Technology, Engineering and Mathematics (STEM).

ISLE is a learning model by playing like a physicist in the process of discovering or creating a science. ISLE learning emphasizes an investigation to find a mystery behind events, students discover a physics concept as a scientist finds something (Etkina et al., 2019). There are two main features in the ISLE model, features related to the development of students' abilities based on their own ideas and features related to students' learning processes (Etkina, 2001). In the learning process students' creative thinking skills can be grown and designed through learning using the ISLE model (Wahyuni et al., 2021).

The ISLE model helps students to better understand physics concepts and study physics like scientists when students build and learn new knowledge with their groups through experiments or practicums. According to the theory of constructivism, the success of learning is determined by the knowledge that students have to build their own learning process actively through real experience. Learning will be more active if students conduct experiments with the help of teaching aids in the learning process. According to Suparno (2006), states that "experiments invite students to conduct experiments as a proof and clarify the truth of a theory".

STEM is one of the learning approaches that can create a fun and independent learning atmosphere (Sasmita et al., 2021). STEM is a learning approach that integrates the four fields of science, including science, technology, engineering and mathematics. The application of ISTEM can help develop knowledge, help answer questions based on research, and can help students to create new knowledge (Permanasari, 2016).

STEM education has been widely adopted in various countries. In Taiwan learning activities have been student-centered and the 9-year learning curriculum has integrated the STEM-based curriculum (Lou et al., 2010). Malaysia involves students aged 13-14 years and then collaborates with America in the STEM field in order to compete in the 21st century economy.

Torlakson (2014) provides an explanation of the four STEM fields, including: Field of Science, namely learning that is closely related to nature and the surrounding environment in terms of physics, chemistry and biology. The field of technology consists of all systems, knowledge, individuals and organizations as well as the processes and devices that create and operate technology. Engineering field, is knowledge about how

to design and operate a procedure. The field of mathematics, learning related to patterns and relationships between equations, numbers, and spaces.

STEM learning gives students a sense of enthusiasm and can improve understanding of concepts for students (Utami, IS et al., 2017). The purpose of STEM education is to improve students' skills in four fields of science including science skills, technology operating skills, problem solving skills and math skills that are very appropriate to be applied in facing the challenges of 21st century learning (Wadia et al., 2019).

The 21st century requires teachers to continue to develop and improve in an effort to improve their competencies. A teacher should have good competence. Competence is a set of components of mastery of abilities that must exist in a teacher to realize his professional performance (Trisoni, 2011). Teacher professional development is a way of developing the competence of a teacher through development programs, training or other courses (Hendriks et al., 2010). Teacher mastery of subject matter has an important role in order to be able to apply the ISLE-based STEM model properly (Putra et al., 2021). It is hoped that the development of ISLE-based STEM approaches and models in physics learning in schools can be a reference for teachers in improving their competencies.

## Method

This study uses the Research and development (R&D) method. Research and development method is a research method that uses scientific methods to research, design, produce and test the validity of a product that has been produced (Sugiyono, 2015). Sukmadinata (2012) explains that research and development is a research process that has been carried out to perfect the finished product with pepper or other to produce a new product.

The product developed in this research is ISLE based STEM learning media to help improve students' understanding in understanding Geometry Optics material. The products produced in this study are: Student Worksheets designed using the ISLE Model with a STEM Approach.

The research and development model used by the author in this study is ADDIE (Analysis-Design-Develop-Implement-Evaluate). According to Tegeh and Kirna (2013: 16) explained that the ADDIE model is a research and development model that is structured systematically and programmed in an effort to solve problems related to appropriate learning resources based on the needs of students.

The description of the stages used in the ADDIE model is as follows (Tegeh and Kirna, 2013): Analysis stage, design stage, development stage, implementation stage, evaluation stage.

The instruments in this study were teacher questionnaires and expert validation sheets on Student Worksheets. The instrument used in the teacher questionnaire consisted of a teacher questionnaire sheet using ISLE-based STEM as well as a learning observation sheet adapted to the standard of observing the learning process used to observe and assess Teacher Professional Education participants. The data analysis technique used in this research is to use descriptive statistics. According to (Sugiyono, 2012) descriptive statistics are statistics that perform data analysis by describing or describing the data that has been collected. To find out the validity score on the Student Worksheet, the researcher used a rating scale. Sugiyono (2013) states that the raw data obtained in the form of numbers on the measurement with a rating scale is then interpreted in a qualitative explanation.

## Result and Discussion

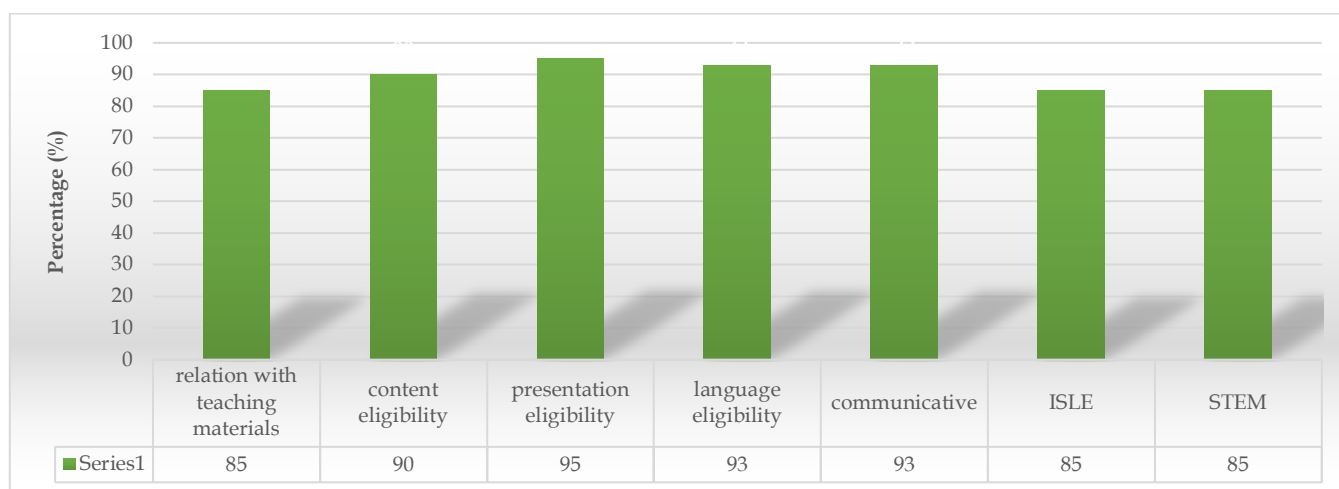
The Student Worksheet validation sheet is given to the validator in the form of a scoring sheet. The validation sheet aims to determine the assessment of the validator regarding the Student Worksheet that is being developed. The assessment by the validator is filled in on the validation sheet in the form of numbers, suggestions and comments. Furthermore, the validation results from the validator are used as reference material for improvement. The data from the material expert validation on the Geometry Optics Student Worksheet is shown in Table 1.

**Table 1.** Data on the results of material expert assessments on Geometric Optical Student Worksheets

Rated aspect	Score		Total	Per-centage (%)	Category
	Expert 1	Expert 2			
<b>Student Worksheet</b>					
Linkage with teaching materials	4.00	4.50	8.50	85.00	Very good
Content eligibility	4.66	4.33	8.99	90.00	Very good
Serving Eligibility	5.00	4.50	9.50	95.00	Very good
Language Eligibility	4.50	4.75	9.25	93.00	Very good
Communicative	4.66	4.66	9.32	93.00	Very good
ISLE	4.50	4.00	8.50	85.00	Very good
STEM	4.00	4.50	8.50	85.00	Very good
Percentage				89.43	Very good

The results of expert validation of the ISLE-based STEM Student Worksheet material on the subject of Geometry Optics conducted by two experts showed a percentage of 89.43% overall in the very good category. In the aspect of linkage with teaching materials, the percentage is 85.00%, 90.00% is in the content feasibility aspect, the presentation feasibility aspect is 95.00%, the

language feasibility aspect is 93.00%, the communicative aspect is 93%, the ISLE aspect is 85.00%, and the STEM aspect is 85%. So that by material experts the Geometry Optics Student Worksheet is considered suitable for use in teaching and learning activities. The material expert validation result diagram is shown in Figure 1.



**Figure 1.** Material expert validation result diagram Furthermore, an analysis of the teacher's questionnaire was carried out

The teacher's questionnaire using the ISLE-based STEM approach and model is designed to see the extent

to which a teacher can implement the ISLE syntax combined with the STEM approach to students. The

teacher questionnaire in this study also aims to assess the professionalism of a teacher. Teacher professionalism needs to be developed in order to improve the quality of teacher competence. Increasing teacher professionalism can be carried out by means of a teacher carrying out learning activities in the classroom and then being

observed by several other teacher colleagues. The teacher's questionnaire analysis regarding the observation of the implementation of ISLE-based STEM learning can be seen in Table 2.

**Table 2.** Teacher questionnaire analysis

Rated aspect	Score			Total	Percentage (%)	Category
	Expert 1	Expert 2	Expert 3			
Teacher Questionnaire						
As per ISLE syntax	3	3	3	9	75.00	Very good
Increase investigative interest	3	3	4	10	83.00	Very good
Think like a scientist	3	3	3	9	75.00	Very good
Technology literacy	3	2	3	8	67.00	Good
Critical and innovative	4	3	2	9	75.00	Very good
Problem solving skills	3	3	3	9	75.00	Very good
Collabora-te	3	3	3	9	75.00	Very good
Communi-cate	4	3	3	10	83.00	Very good
Concept unders-tanding	4	3	3	10	83.00	Very good
STEM Integra-tion	3	3	2	8	67.00	Good
According to K-13 standard	2	3	3	8	67.00	Good
Geometry Optics						
The propaga-tion of light in the mirror	3	3	3	9	75.00	Very good
The path of light on a parallel plan glass	3	3	3	9	75.00	Very good
Determi-nation of refractive index	3	3	3	9	75.00	Very good
Determi-nation of special rays in mirrors and lenses	3	3	3	9	75.00	Very good
Total					1125.00	
Average Percentage					75.00	Very good

**Table 3.** Learning Observations

Rated aspect	Score			Total	Percentage (%)	Category
	expert 1	Expert 2	Expert 3			
Learning Observation						
Initial activity	3.75	3.00	3.50	10.25	85.00	Very good
Material mastery	3.25	3.00	3.00	9.25	77.00	Very good
Applicati-on of Educational Approach-es/Strate-gies/Le-arning Models	3.75	3.00	3.50	10.25	85.00	Very good
Applicati-on of Scientific Approach	3.50	3.00	3.25	9.75	81.00	Very good
Applicati-on of Integrated Thematic Learning	3.75	3.00	3.00	9.75	81.00	Very good
Involve-ment of Students in Learning	3.75	3.00	3.00	9.75	81.00	Very good
Use of Learning Methods	4.00	3.00	3.00	10.00	83.00	Very good
Utilizati-on of Learning Media	3.25	3.00	3.25	9.50	79.00	Very good
Utilizati-on of Learning Resources	2.75	3.00	3.00	8.75	73.00	Good
Good and Correct Use of Language	3.00	3.00	2.75	8.75	73.00	Good
Closing Activities	3.50	3.00	3.25	9.75	81.00	Very Good
Total					879.00	
Average Percentage					80.00	Very good

Based on the results of the teacher's questionnaire analysis in ISLE-based STEM learning, the average teacher questionnaire assessment results overall are 75.00%, which means the ability of a teacher studied in

teaching using the ISLE-based STEM approach and model is in the very good category. Learning observations made by several fellow teachers received an average rating of 80.00% with a very good category.



The first step of this research based on the ADDIE model is to analyze the implementation of the ISLE-based STEM approach and model in schools by conducting interviews with physics teachers to find out about the conditions of physics learning that has been taught in schools. Based on the interview, it was found that the teacher played a more active role in building the learning process and understanding of students. So, it is necessary to apply approaches and models that make students gain their own knowledge with their group friends and the teacher acts as a facilitator in it. The approach and model used by the researcher is ISLE-based STEM and is applied to the subject of Optical Geometry.

The second stage of this research is the design stage. The design is in the form of learning tools such as Student Worksheets based on ISLE syntax and the design of teacher guides. The third stage is the development stage, after the learning design is completed, the researcher conducts a limited test with several students in order to determine the effectiveness of the learning tools being developed. Furthermore, the validation of the Student Worksheets was carried out to several expert validators. The assessment by the validator is filled in on the validation sheet in the form of numbers, suggestions and comments. The results of expert validation of the ISLE-based STEM Student Worksheet material on the subject of Geometry Optics conducted by two experts showed an average percentage of 89.43% in the very good category. So that by material experts the Geometry Optics Student Worksheet is considered suitable for use in teaching and learning activities. The fourth stage is the implementation stage, which means the application of the ISLE-based STEM approach and model to students at school.

## Conclusion

Based on the research that researchers have done, it can be concluded that this development research resulted in ISLE-based STEM Student Worksheets on the topic of Geometry Optics. The research and development model used is the ADDIE (Analysis-Design-Develop-Implement-Evaluate) model. The Student Worksheet has been validated by material experts with an average percentage of 89.43% and got a very good category. Based on the results of the teacher's questionnaire analysis in ISLE-based STEM learning, the average teacher questionnaire assessment results overall are 75%, which means the ability of a teacher studied in teaching using the ISLE-based STEM approach and model is in the very good category. Increasing teacher professionalism can be carried out by means of a teacher carrying out learning activities in the classroom and then being observed by several other teacher colleagues.

Based on the results of learning observations in the classroom, an assessment of 80% was obtained on the learning observation sheet with a very good category.

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