DEVELOPMENT OF POE (PREDICT-OBSERVE-EXPLAIN) TEACHING MODULES TO IMPROVE STUDENTS' SCIENTIFIC THINKING SKILLS IN SCIENCE SUBJECTS

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Abstract

The ability to think scientifically is an ability that students must have to face 21st century life. One way that can be done to improve students' scientific thinking skills is to apply the POE learning model to the teaching modules used. One way that can be done to improve students' scientific thinking skills is to apply the POE learning model to the teaching modules used. The POE learning model is a learning model that focuses on three main activities, namely predicting, observing, and explaining. In this study, the goal to be achieved is to find out the validity of teaching modules, the practicality of teaching modules, and the effectiveness of teaching modules in improving scientific thinking skills. This research will be conducted using the Borg n Gall model RnD method. The results of the research obtained in this research can be seen that the POE teaching module has been declared valid by validators, the level of practicality of the teaching module developed at the limited trial stage is classified as practical for teachers and very practical for students, then at the wide-scale trial stage the practicality level of the teaching module is classified as very practical both by teachers and students, The teaching modules developed have been said to be effective in improving students' scientific thinking skills, this is due to an increase in N-gain scores from limited trial stages to wide-scale trials of 0.022.

Keywords: *Development, Teaching Module, POE (Predict-Observe-Explain), Scientific thinking skills*

Abstrak

Kemampuan berpikir ilmiah merupakan kemampuan yang harus dimiliki siswa untuk meghadapi kehidupan abad 21. Salah satu cara yang dapat dilakukan untuk meningkatkan kemampuan berpikir ilmiah siswa adalah dengan menerapkan model pembelajaran POE pada modul ajar yang digunakan. Model pembelajaran POE merupakan model pembelajaran yang memfokuskan pada tiga kegiata utama yakni memprediksi, mengamati, dan menjelaskan. Dalam penelitian ini tujuan yang ingin dicapai adalah mengetahui validitas modul ajar, kepraktisan modul ajar, dan efektifitas modul ajar dalam meningkatkan kemampuan berpikir ilmiah. Penelitian ini akan dilakukan dengan metode RnD model Borg n Gall. Hasil penelitian yang diperoleh pada penelitian kali ini dapat dilihat bahwa modul ajar POE telah dinyatakan valid oleh para validator, tingkat kepraktisan modul ajar yang dikembangkan pada tahap uji coba terbatas tergolong pada kategori praktis bagi guru dan sangat praktis bagi siswa, kemudian pada tahap uji coba skala luas tingkat kepraktisa modul ajar tergolong pada kategori sangat praktis baik oleh guru dan juga siswa, modul ajar yang dikembangkan telah dikatakan efektif dalam meningkatkan kemampuan berpikir ilmiah siswa, hal ini dikarenakan adanya peningkatan skor N-gain dari tahapan uji coba terbatas ke uji coba skala luas sebesar 0,022.

Kata kunci: *Pengembangan, Modul Ajar, POE (Predict-Observe-Explain), Kemampuan berpikir ilmiah*

Introduction

Education plays a crucial role in preparing students to fulfill the skill requirements of the twenty-first century. According to Sujana, the skills required in the 21st century are critical thinking, creativity, communication, and collaboration, or 4C skills (Mukarramah et al., 2021). Science subjects are one of the subjects that can be used to satisfy the requirements of the 21st century. (Rifa'i et al., 2021) Integrative science refers to the branch of science that investigates a variety of natural occurrences through a succession of scientific activities. This is also consistent with the nature of science, which regards science as a product, a process, and a scientific disposition (Sayekti, 2019).

Students at the MTs level have entered adolescent development when viewed from the perspective of their age. According to developmental psychology, a person's cognitive capacities enter the formal operational stage during adolescence. A teenager at this age is able to determine which ideas are more essential than others. Moreover, adolescents are able to organize their way of reasoning in order to generate new ideas (Jahja, 2015). In this way, science contributes to student development by fostering scientific thinking skills.

According to Kuhn's assertion, this scientific thinking ability is a study of higher-order thinking skills because, through this ability, the human way of thinking will expand and become more systematic (Nurya et al., 2021). There are four indicators of the capacity to think scientifically. These indicators include the students' ability to think introspectively, analytically, inferentially, and express their opinions (Agustina et al., 2020).

Based on a literature review conducted in previous research conducted by Aisyah et al in high schools located in the mountainous region of Yogyakarta, it was determined that students' scientific thinking skills remained in the low category because the overall average was less than 50 percent (Anggraini et al., 2018). Zensi Dermawan et al. found in a previous study at SMAN 1 Kalasan Sleman that the school's pupils were still in the category of less or still low. This is due to the fact that, according to Darmawan et al. (2018), the average score of student acquisition is still in the range of 50.28. Based on these two investigations, it is evident that the scientific reasoning skills of Indonesian students are still inadequate.

The availability of high-quality teaching materials affects students' capacity to receive and comprehend the material presented (Adumiranti & Widyaningrum, 2021). It is believed that instructional modules designed to enhance scientific thinking skills can effectively prepare students for life in the twenty-first century.

The teaching module based on the POE learning model was designed to improve the scientific reasoning abilities of students. (Rahmawati et al., 2019) According to Rustami, this learning paradigm efficiently improves students' conceptions of science and helps students generate new ideas or concepts. On this basis, it is believed that the POE learning model improves students' scientific reasoning abilities.

Method

This investigation is an example of R&D or Research and Development (R&D) research. The model of development utilised in this investigation is the Borg and Gall model. According to Borg and Gall, development research is a type of research that seeks to develop and validate an educational product (Ainin, 2013). This model stipulates that the phases of development must pass through 10 steps.

This research data was collected by the educational institution MTsN 1 Ponorogo. The subjects of this research were 7F and 7D grade students. Other research participants in this study are experts or validators who play a role in evaluating the developed POE-based instructional modules. Following are the steps researchers take when conducting research activities:

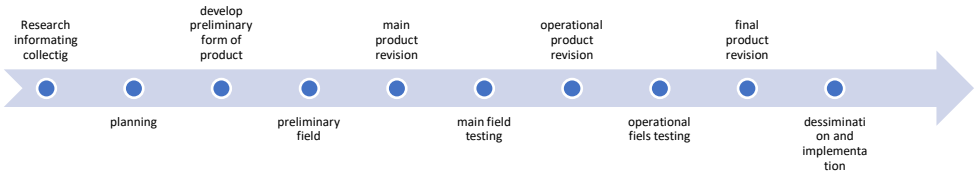

Figure 1. Research steps

Result and Discussion

In the current research, findings will be based on information regarding the validity and dependability of teaching modules, the usefulness of teaching modules for students and teachers, and the efficacy of POE-based teaching modules. The following are the outcomes of Borg and Gall model-based development research:

1. Research and information collecting

Through the use of test queries, researchers collect data on the scientific reasoning abilities of students at this stage. The average score obtained by students after answering this test question was 62.41. This average value continues to be moderate. On the basis of these findings, researchers determined that the scientific reasoning skills of MTsN 1 Ponorogo pupils must be enhanced through the development of POE (Predict-Observe-Explain)-based instructional modules.

2. Planning

The researcher decided to plan the creation of teaching modules based on the POE learning model based on the initial data collected. In the preparation of teaching modules, researchers also consider the characteristics of effective teaching modules as a point of reference. This instructional module is self-instructional, self-contained, independent, adaptable, user-friendly, and consistent (Sunantri, 2018). At this stage, the development of features that will be presented in this POE-based instructional module is also being planned and organised. The following characteristics will be demonstrated in the instructional module: a) Cover, b) Introduction, c) Table of contents, d) Concept map, e) Module usage instructions, f) Content, g) Content summary, h) Practise questions, i) QR code containing video links, j) Bibliography, and k) Glossary. In addition, researchers determine the KI-KD and test question grids that will be used to evaluate scientific thinking abilities at this stage.

3. Develop preliminary form of product

At this stage, researchers began to develop product designs for POE-based teaching modules. The following describes the design of teaching modules carried out by researchers:

Figure 2. Cover

Figure 3. Concept map

Figure 4. Module instructions

4. Preliminary field testing

At this juncture, the developed teaching modules will be given to three expert validators, one science lecturer and two science teachers from MTsN 1 Ponorogo. The following are the outcomes of the validation performed by the three validators:

Table 1. Aiken V Test Results Media Aspects

Assessment Aspect	Indikator	V1	V2	V3	Total	*Aiken's V* test results	Criteria
Module	In accordance with ISO standards	5	5	5	15	1,00	Valid
	The composition of the margins corresponds to the paper size and content of the material	5	5	5	15	1,00	Valid
Cover Module	The illustration on the cover illustrates the contents of the module	5	5	5	15	1,00	Valid
	The fonts used are attractive	5	5	5	15	1,00	Valid
	The selection of the title font color contrasts with the background color	5	5	5	15	1,00	Valid
	There are not too many letter combinations used in the module	5	5	5	15	1,00	Valid
	The proportion of the size of the important items in the module corresponds	5	5	5	15	1,00	Valid
Content Design Module	The font size used in the material is proportional	5	5	5	15	1,00	Valid
	Layout arrangement between materials, text, images, and diagrams accordingly	5	5	5	15	1,00	Valid
	The images displayed in the module are interesting	5	5	5	15	1,00	Valid
	The images displayed in the module are clear	5	5	5	15	1,00	Valid
	The spaces used between letters are proportional	5	5	5	15	1,00	Valid
	The spacing used between lines is proportional	5	5	5	15	1,00	Valid

Table 2. Aiken V Material Aspect Test Results

Component	Indicator	V1	V2	V3	Total	*Aiken's V* test results	Criteria
Self instruction	Learning objectives are in accordance with KD and KI in the curriculum, namely Indonesian Ecology and Biodiversity	5	5	5	15	1,00	Valid
	The material is in accordance with KI and KD, namely Indonesian Ecology and Biodiversity	5	5	5	15	1,00	Valid
	The material is presented systematically (general to particular)	5	5	5	15	1,00	Valid
	Indonesia's Ecology and Biodiversity material is easily understood by students	5	5	5	15	1,00	Valid

	Illustrations or images presented in accordance with the context of Indonesian Ecology and Biodiversity material	5	5	5	15	1,00	Valid
	The problems presented in the module can be contextual in everyday life	5	5	5	15	1,00	Valid
	The problems presented in the module are able to stimulate students' analytical abilities	5	5	5	15	1,00	Valid
	The problems presented in the module are able to stimulate students' inquiry abilities	5	5	5	15	1,00	Valid
	The problems presented in the module are able to stimulate students' inference skills	5	5	5	15	1,00	Valid
	The problems presented in the module are able to stimulate students' argumentation skills	5	5	5	15	1,00	Valid
Self contained	The module contains one material in accordance with the KD of Indonesian Ecology and Biodiversity	5	5	5	15	1,00	Valid
Stand alone	The material in the module covers the entire material without the need for other teaching materials	5	5	5	15	1,00	Valid
Adaptive	The module content is tailored to the demands of students able to think creatively	5	5	5	15	1,00	Valid
	The module content is tailored to the demands of students able to think critically	5	5	5	15	1,00	Valid
	The module content is adjusted to the demands of students being able to collaborate	5	5	5	15	1,00	Valid
	The module content is tailored to the demands of students able to communicate	5	5	5	15	1,00	Valid
	The content of the module is able to invite students to make predictions	5	5	5	15	1,00	Valid
	The content of the module is able to invite students to make observations	5	5	5	15	1,00	Valid
	The content of the module is able to invite students to explain	5	5	5	15	1,00	Valid
User friendly	Modules are easy for students to learn	5	5	5	15	1,00	Valid
	Flexible modules to take anywhere by students	5	5	5	15	1,00	Valid

Table 3. Aiken V Language Aspect Test Results

Component	Indicator	V1	V2	V3	Total	*Aiken's V* test results	Criteria
Language	Language used according to PUEBI	5	5	5	15	1,00	Valid
	The language used is easy dipahami	5	5	5	15	1,00	Valid
	The sentence used does not have a double meaning	5	5	5	15	1,00	Valid

Eligibility	The language used is in accordance with the level of thinking development of students	5	5	5	15	1,00	Valid
	Sentences used effectively	5	5	5	15	1,00	Valid
	Spelling and punctuation are in accordance with the rules of writing Indonesian	5	5	5	15	1,00	Valid
Interactive	The language used can encourage students to ask questions	5	5	5	15	1,00	Valid
	The language used has a two-way aspect between the writer and the reader	5	5	5	15	1,00	Valid

Table 4. Aiken V Test Results Scientific Thinking Ability Test Questions

Component	Indicator	V1	V2	V3	Total	*Aiken's V* test results	Criteria
Material	The questions are in accordance with the material of Indonesian Ecology and Biodiversity	5	5	5	15	1,00	Valid
	Questions according to the POE (*Predict-Observe-Explain*) indicator	5	5	5	15	1,00	Valid
	The answer options presented are homogeneous and logical	5	5	5	15	1,00	Valid
	There is only one correct answer	5	5	5	15	1,00	Valid
	The questions correspond to the measured cognitive realm	5	5	5	15	1,00	Valid
Construction	The questions are formulated concisely, clearly, and firmly	5	5	5	15	1,00	Valid
	The question does not give a clue to the answer key	5	5	5	15	1,00	Valid
	The subject matter is free from statements that are double negative	5	5	5	15	1,00	Valid
	The figures and tables used are clear and can be used as a reference for students	5	5	5	15	1,00	Valid
	Answer choices do not use the "All answers are true/false" option	5	5	5	15	1,00	Valid
	The given options are accompanied by a description of the reasons	5	5	5	15	1,00	Valid
Language	The language used is in accordance with PUEBI rules	5	5	5	15	1,00	Valid
	The language used is communicative	5	5	5	15	1,00	Valid
	The language used does not mean double	5	5	5	15	1,00	Valid
	The language used does not occur waste of words	5	5	5	15	1,00	Valid

On the basis of tables 1, 2, 3, and 4, it has been determined that the developed teaching modules and test questions are valid. The reliability of the test questions was also evaluated using the alpha-Cronbach formula. The received reliability value of 0.774 is deemed reliable. This decision was made in accordance with the theory that if the Cronbach's Alpha value is greater than 0.70, it is considered reliable (Adumiranti & Widyaningrum, 2022). (Matondang,

2009) According to Azwar, the existence of this reliability is one of the crucial factors for a measurement instrument to be deemed effective.

5. Main product revision

At this stage the researcher makes improvements to the module. The following is input provided by validators as a reference used to improve the teaching modules developed:

Table 5. Suggested revisions by validators

No.	Validator	Notes on Revision of Teaching Module Development
1.	Validator 1	1. Correct the word "above" in some sections because the referenced section is not at the top but is on the previous page 2. Fix the sentence structure that still confuses the reader 3. Change the image showing Wallace and webber lines with a clearer image 4. Fix images that are not right with the content of the material 5. Improve the shape of the concept map 6. Add picture explanations about individuals, populations and communities
2.	Validator 2	1. Fix sentence waste in some parts 2. Add the caption "observe the image below" above the image 3. Add explanatory material regarding the definition of organisms 4. Fix the shape of the diagram 5. Add images of food webs
3.	Validator 3	1. Fix the appearance of the cover 2. Improve the writing of image sources 3. Add an exclamation mark to the command sentence

The following is the result of improvements to the initial design of teaching modules that have been made.

Figure 5. Cover before revision

Figure 6. Cover after revision

In the cover section, improvements were made to writing the title of the content of the material. Before the fix, after the circle there is a symbol (-) so that the symbol is removed and a space is added between the headings of the content of the material in the module.

Figure 7. Concept map before revision

Figure 8. Concept map after revision

Improvements to the concept map are made by improving the shape and arrangement of the existing concept map. Before the improvement, the concept map only showed the subchapter headings in the module without explaining in each subchapter what material would be studied.

Figure 9. Display of contents before revision Figure 10. Display of contents after revision

Improvements to this section are shown in the addition of the inscription "Observe the image below". The addition of this sentence is done to make it easier for students to use the teaching module.

Gambar 11. Display of material before revision

Gambar 12. Display of material after revision

Improvements were also made by adding images of the embodiment of individuals, populations, and communities to make it easier for students to understand the definitions that have been submitted.

6. Main field testing

At this stage researchers began to conduct limited trial activities of teaching modules that had been developed. Here is a breakdown of the results at this stage:

a) Practicality of teaching modules for teachers

A science teacher collected the data used to ascertain the level of practise of the teaching module for teachers through the completion of a questionnaire. The following are the results of instructors' practical observations:

Table 6. Limited Trial Teacher Practicality Test Results

Assessment Aspect	Score	Maximum Score	Percentage
Instruction	10	10	100%
Fill	9	10	90%
Serving	14	15	80%
Language	7	10	70%
Total	36	45	

Based on table 6, by looking at the total score obtained in the practicality test, the level of practicality possessed by the teaching module in this stage is classified as a practical category.

b) Practicality of teaching modules for students

The practicality evaluation of teaching modules is also applied to students who serve as research subjects and receive teaching modules as supplementary learning materials. The following are the results of students' experimental observations:

Table 7. Limited Trial Student Practicality Test Results

Number of Respondents	Assessment Aspect	Assessment Score	Maximum Score @Aspect	Maximum Score x Respondents
10	Goals	73	10	100
	Fill	73	10	100
	Serving	114	15	150
	Language	78	10	100

Total Assessment Score	337	45	40
Average Assessment Score		37,44	

Based on table 9, the total score obtained in the practicality test shows that the level of practicality possessed by the teaching module in this stage is classified as very practical.

c) Test the effectiveness of teaching modules

At this point, a paired t test analysis was performed, and a significance result of 0.001 was obtained. Therefore, it was determined that modules based on the PEO have been effective in enhancing students' scientific reasoning skills. The N-Gain test is conducted to determine the module's effectiveness. The obtained average value is 0.3644. According to Hake, if the N-Gain score falls within the range of 0.3 to 0.7, it is classified as medium (Wahab et al., 2021).

7. Operational product revision

At this stage, the product is once more repaired based on the results of observations of extant flaws. The following are the results of a limited trial of the revised instructional module:

Figure 13. Module instructions before revision

Figure 14. Module instructions after revision

The module's usage instructions have been updated with more comprehensible language. The function of communicative language in facilitating the delivery of content to students is crucial. This is due to the fact that communicative language is a language that effectively conveys messages (Devianty, 2019).

8. Operational field testing

At this stage, trial activities are carried out by applying the module more broadly. The following is the acquisition of data received.

a) Practicality of teaching modules for teachers

The data used to ascertain the level of practice of the teaching module for teachers was gathered through the completion of a questionnaire administered by an MTsN 1 Ponorogo science teacher. The following are the results of instructors' practical observations:

Table 9. Limited Trial Teacher Practicality Test Results

Assessment Aspect	Score	Maximum Score	Percentage
Instruction	10	10	100%
Fill	9	10	90%
Serving	15	15	100%
Language	10	10	100%
Total	45	45	

Based on table 10 by looking at the total score obtained in the practicality test, the level of practicality possessed by the teaching module in this stage is classified as very practical.

b) Practicality of teaching modules for students

The following are the results of practical observations made by students:

Table 10. Limited Trial Student Practicality Test Results

Number of Respondents	Assessment Aspect	Assessment Score	Maximum Score @Aspect	Maximum Score x Respondents
10	Goals	223	10	270
	Fill	214	10	270
	Serving	349	15	405
	Language	233	10	270
Total Assessment Score		1019	45	1215
Average Assessment Score			37,74	

Based on table 10, by looking at the total score obtained in the practicality test, the level of practicality possessed by the teaching module at this stage is classified as very practical.

c) Effectiveness Test

At this point, analysis calculations will be performed using a paired T test with an obtained significance value of 0.000. If the sig is greater than 0.05, it can be concluded that the instructional module was effective in enhancing students' scientific reasoning skills. Humans possess the capacity to think scientifically in order to increase their knowledge (Rahayu et al., 2013). The N-Gain test was conducted to determine the level of efficacy, yielding an average score of 0.3866, indicating that the practicality category of this instructional module remains in the medium range (Wahab et al., 2021).

9. Final product revision

Revision was again carried out to improve the teaching modules developed. Improvements were made by adding glossary features.

10. Dissemination and implementation

At this point, the dissemination questionnaire was distributed to the five instructors, which consisted of four assessment criteria: purpose, content, design, and language. Following are the results of the evaluation of the questionnaire administered by science instructors in MTsN 1 Ponorogo. Based on the survey results, all teachers agreed that the POE teaching module should be broadly disseminated in all four categories.

Conclusion

On the basis of the research and discussions conducted, the following conclusions can be drawn: (1) POE-based teaching modules are valid and reliable for use in learning activities; (2) POE-based teaching modules have been practical to use; and (3) POE-based teaching modules have been effective in enhancing students' scientific thinking skills.

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