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Effectiveness of Guided Inquiry-Based Mosiry E-Module on the Immune System in Improving Students' Integrated Science Process Skills (SPS)

Yanti Sulistyana, Meti Indrowati and Joko Ariyanto

Sebelas Maret University, Indonesia

Abstract: Integrated Science Process Skills online learning cannot be taught optimally so learning media are needed that can teach integrated, interactive, and practical SPS. One such media is an e-module. This study aimed to determine the feasibility and effectiveness of Guided Inquiry-Based e-module, or Mosiry, in improving Integrated SPS of Class XI students in the Immune System subject. This research is a developmental research, using the 4D development design stages: 1) Defining; 2) Designing; 3) Developing; and 4) Disseminating. The sample was selected using a purposive sampling method. Data was collected by using observation, interviews, questionnaires, and pre-test/post-test; and data was analysed based on media feasibility, and effectiveness analysis. The results of this study were that the Mosiry e-module is suitable for use as a learning medium for the Immune System and could improve students' SPS in the moderate category.

Keywords: e-modules, guided inquiry, integrated SPS, and the immune system.

Introduction

Integrated Science Process Skills (SPS) empower students to be able to answer their questions, interpret what they observe, and design experiments to test their ideas (Evriani et al., 2017). Based on the Regulation of the Minister of Education and Culture or Permendikbud (Indonesian), No. 21/2016, the skill of designing an investigation with the correct procedure is one of the competencies that must be achieved in secondary level Biology learning. Integrated SPS trains students to formulate hypotheses, identify variables, define variables operationally, describe relationships between variables, and organise data in tables and graphs to achieve an understanding of the material (Joefrey, 2017). Improved integrated SPS enables students to better understand concepts, processes, and positive attitudes; students are expected to properly and correctly apply concepts that are understood in everyday life as a provision for them in dealing with social life (Asis, et al., 2021; Stephen, 2019). Integrated SPS must be taught because it plays a role in formal and lifelong education (Leonor, 2015).

Based on data from the 2020 Ministry of Education and Culture, Indonesia, it is known that the results of the 2019 Biology National Examination proved that mastery of Biology material had not reached 50%, especially with abstract material (Kemendikbud, 2020). Based on Schleicher's 2018 data report on the 2018 PISA ranking in the field of science (Schleicher, 2018), it is known that Indonesia was still ranked 69 out of 71 countries, with a score of 396 points out of the highest total

of 707.93 points. Students' integrated SPS is still lacking, including the ability to hypothesise (Fitriana et al., 2019), communicate (Elvanisi et al., 2018), predict, determine variables, investigate, analyse, and arrive at conclusions (Yunita, 2021). The integrated SPS of 11th-grade science high school students in Thailand is low, in descending order of formulating hypotheses, experimenting, interpreting data, making conclusions, operationally defining variables, identifying variables, and controlling variables (Seetee et al., 2016). The low integrated SPS can cause students' understanding of the material to be low, especially for abstract material such as the Immune System material. The Immune System material is complex (Sumari, 2020) because it is so abstract and students find it challenging to visualise the material, especially the working mechanism of the immune system (Raida, 2018), and the structure of antibodies or antigens (Dawson et al., 2014). Teachers also have difficulty in designing learning strategies for the Immune System material because there are many sub-materials in the Immune System material. So, to present this material, the teacher completes it by using the lecture method (Raida, 2018).

Based on these facts, one of the factors that can cause a lack of integrated SPS for students is the learning model. Lecture learning does not expose students to problem-solving so students learn passively. This is exacerbated by online learning, where students have only a very short study time, and because some material is delivered only through videos, students interact just briefly with their teacher, so students can be more passive in their learning. Passive students have difficulty acquiring their SPS (Sulistri et al., 2018). The learning model thought to help improve students' SPS is the guided inquiry method (Derilo, 2019; Yildirim et al., 2016). The guided inquiry learning model can improve SPS because, in the learning stage, it provides many opportunities for students to seek and find facts on their own through direct experience so that learning can be said to run optimally (Rizal, 2014).

Based on the problems that have been described, it is necessary to have learning media that can apply guided inquiry learning, material visualisation, and interactive and practical study so that students can train in integrated SPS during online and offline learning (Sumari, 2020). The learning media offered are multimedia, namely, the combination of more than one media, including sound, text, graphics, animation and video (Marjuni, 2019) into an interactive relationship (Darmawan, 2012). E-modules are multimedia because they can contain practical learning materials, methods, and evaluations (Istuningsih et al., 2018; Wibowo, 2018) and images, videos, and material links can be included to help students visualise the material and create experiences and new learning as well as practice questions (Hafsah et al., 2016; Serevina, 2018). The use of e-modules in online and offline learning is necessary because learning can never be separated from technological developments.

Based on the background that has been stated, it is necessary to develop a Guided Inquiry-based Mosiry e-module. To analyse the results of the research, the objectives of this research are:

1. What is the feasibility of the Guided Inquiry-based Mosiry e-module on the Immune System as a learning medium for Class XI Science students?
2. What is the effectiveness of the Guided Inquiry-based Mosiry e-module in improving the integrated SPS of Class XI Science students on the Immune System?

Methods

Research Design

The method used in this study was the 4-D method, which has four stages, namely Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974; Lestari, 2018). The 4-D method is more concise but includes all stages so that it can produce products that meet good criteria and are empirically tested, that there is an analysis of the curriculum, which is the main reference in learning, and that there is an analysis of tasks and concepts that play a role in the goals and design of learning media. The products developed are then tested for feasibility and effectiveness.

Population and Sample

The population in this study included students of Class XI Science Senior High School in one of the schools in Surakarta City, Central Java Province, Indonesia, with a total of 203 students. The sample in this study was students of Class XI Science 4, totaling 30 students for limited trials and for large-scale trials. two other classes, namely, students of Class XI Science 1 as the control group, totaling 41 students, and students of Class XI Science 2 as the experimental group, which totaled 41 students.

The purposive sampling method determined the sample (Lenaini, 2021). Samples were selected based on class homogeneity, class distribution, Class XI Science in the even semester, receiving immune system material, and owning a smartphone/laptop. The main requirement for allocating classes into control and experimental groups was that the class was homogeneous and normally distributed, which can be seen from the scores of students for each class on the semester exams.

Tools and Techniques

Data collection used three techniques, namely: observation, interviews, and questionnaires. The observation technique was systematic observation and recording of the symptoms that appeared in the object of research. The interview technique collected information by asking questions orally, and these were then answered orally as well. The questionnaire technique is the collection of information by asking written questions, which are then answered in writing. There were three questionnaires in this study, namely a product validation questionnaire, a needs analysis questionnaire, and a response questionnaire (Meilina et al., 2020).

Mosiry E-module Validation: Validation was done to check whether or not the learning media developed was valid. The preparation of the e-module validation sheet was based on a materials grid, media, and learning assessment instruments.

Response Test: The response test was used to determine the response of students and education practitioners to the developed Mosiry e-module. Positive student responses can be used as a benchmark so that students feel more comfortable with the learning media used in the learning process (Nugraha et al., 2013). The response test was carried out twice, namely, the small group response test and the large group response test. The small group test aimed to determine the feasibility of the media and its revision, and the large group test aimed to determine student responses to the media.

Effectiveness Test: The effectiveness test was carried out using the Pre-test/Post-test Control Group Design. Pre-test/Post-test Control Group Design is a form of an experiment involving two groups, namely, the experimental group and the control group, which were selected through purposive sampling. The pre-test and post-test aimed to compare the data before and after being given treatment (Khaatimah, 2017). The use of this technique aimed to determine the effectiveness

of the Mosiry e-module in improving the integrated SPS of Class XI students on the material of the Immune System.

Data Analysis Technique

Qualitative Analysis

Qualitative data were obtained from observations, interviews, suggestions, and input from validators, as well as suggestions and input from the distribution of response tests to the Mosiry e-module based on Guided Inquiry for the Immune System material for Class XI Senior High School.

Quantitative Analysis

Quantitative data were obtained from the results of needs analysis, media feasibility analysis, and media effectiveness analysis. The results of the questionnaire analysis of student needs and media feasibility analysis were in the form of a checklist (√) with a Likert Scale of 1 to 4, which has a gradation of choice from very positive to very negative, without hesitation choices. The Likert Scale can be used to measure the opinions, attitudes, and perceptions of a person or group (Sugiyono, 2013). Likert Scale criteria are listed in Table 1.

Table 1: Criteria for the Likert Scale.

Criteria	Number
Very good	4
Nice	3
Less	2
Much less	1

(Meilina et al., 2020, p. 46)

The validation analysis data collected was converted into percentage form through the formula:

$$PS = n / N \times 100\%$$

Information:

PS = score percentage

N = total score obtained

N = maximum score

(Akbar, et al., 2017, p. 137)

The validation data presented were then categorised as validity/level of media feasibility. Media eligibility categories are listed in Table 2.

Table 2: Media Eligibility Category.

Eligibility Criteria	Eligibility Level	Category
85.01 % - 100.00 %	Very valid/appropriate	Can be used without revision
70.01 % - 85.00 %	Valid/appropriate	Can be used but minor revision
50.01 % - 70.00 %	Less valid/good	It is recommended not to use because of major revision
01.00 % - 50.00 %	Invalid/appropriate	Cannot be used

(Wulandari et al., 2020)

Data analysis of effective results were in the form of pre-test/post-test scores. The pre-test/post-test values were then calculated using the Normalisation-Gain (N-Gain) test formula, which is as follows:

$$N\ Gain\ =\ \frac{Post-test\ Score\ -\ Pre-test\ Score}{Ideal\ Score\ -\ Pre-test\ Score}$$

(Nismalasari et al., 2016, p. 190)

The resulting N-Gain value is then categorised based on the level of the N-Gain value. The category of N-Gain values is shown in Table 3.

Table 3: Category N-Gain.

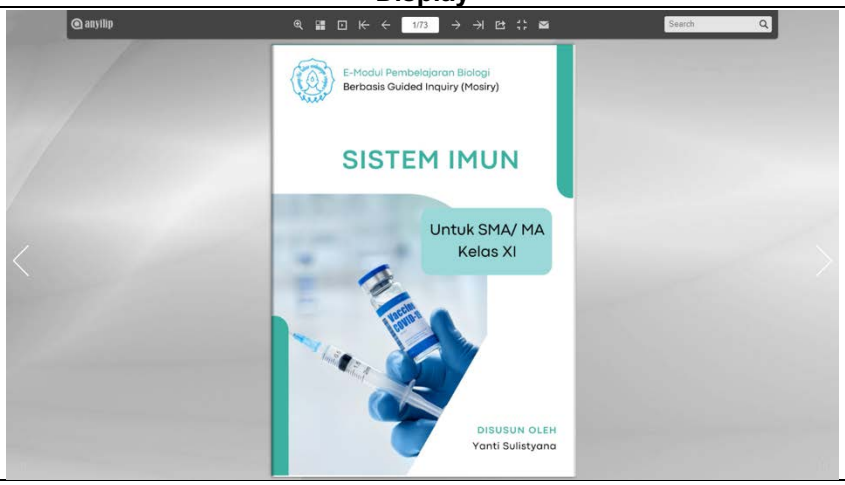
N-Gain Value	Interpretation
0.7 ≤ g ≤ 1	High
0.3 ≤ g < 0.7	Medium
0 < g < 0.3	Low
g = 0	No increase
-1 ≤ g ≤ 0	There is a decrease

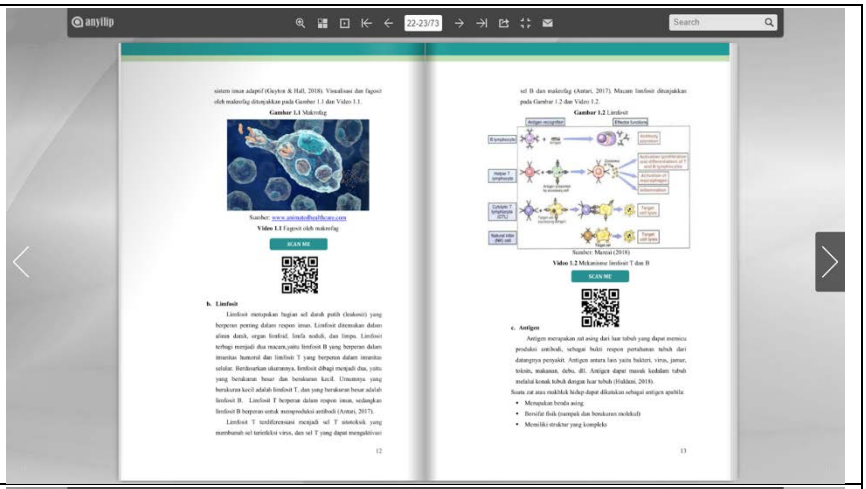
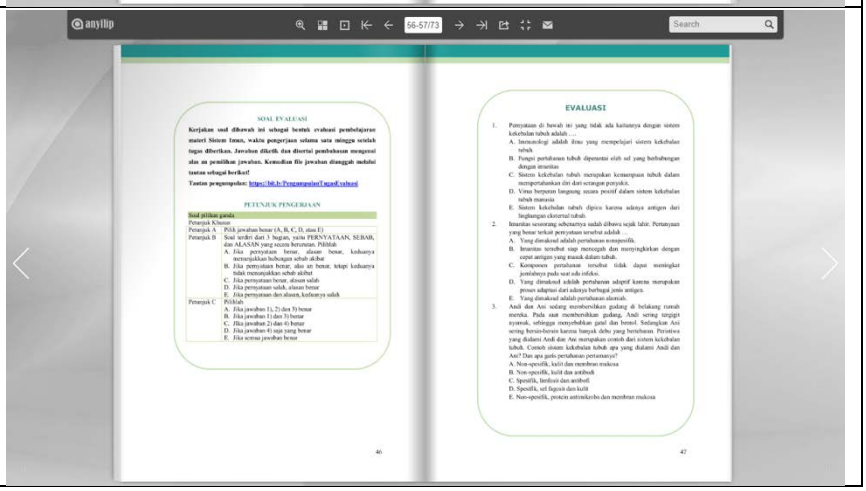
(Sundayana, 2014)

Results

This research focused on developing a Mosiry e-module based on Guided Inquiry to improve students' integrated science process skills on the immune system. The Mosiry e-module was accessed via the internet in the search menu or via the link provided by the teacher. The Mosiry e-module could be accessed anytime and anywhere. The e-module has a book-like appearance and could be opened according to page order or you could skip several pages, either back to the previous page or to the earliest or last page. It could be set to open pages automatically, search every word and zoom in or out. Page minimisation could be shared with other students via email or through other communication channels. The e-module had links to materials, and assignments. Links could be visited using a smartphone scan and directly link the user with material, assignments or a collection of assignments. The link could also contain a video explaining the material or assignment stimulus.

Table 4: Components in the Mosiry E-module.

No.	Description	Display
1	There was a menu zoom in, thumbnails, auto flip, first, previous, page, next page, last, social share, enable full screen, and share.	

2	Students could access a scan code in the material section of the Mosiry e-module.	
3	Students could access a scan code in the assignment section of the Mosiry e-module.	

The e-module contained material on the immune system that could be used to learn biology online and offline. The Mosiry e-module focused on investigative activities based on everyday problems presented by the applicable curriculum. Before distributing the e-module, an e-module assessment was done based on the material, the media, and the learning experts. In addition to biology teachers and students, through a limited-scale field test, the following data were generated, as given in Tables 5, 6 and 7.

Table 5: Material Expert Assessment Results Data.

No.	Assessment Aspect	Value	Category
1.	Content feasibility aspect	98%	Very valid
2.	Aspek kelayakan penyajian	92.86%	Very valid
	Average	96.43%	Very valid

Table 6: Media Expert Assessment Results Data.

No.	Assessment Aspect	Value	Category
1.	Language and readability aspects	98%	Very valid
2.	Aspects of the feasibility of graphics	90.63%	Very valid
	Average	95.31%	Very valid

Table 7: Learning Expert Assessment Results Data.

No.	Assessment Aspect	Value	Category
1.	Aspects of Guided Inquiry	75%	Valid
2.	Integrated SPS aspects	80%	Valid
	Average	77.50%	Valid

Table 5 shows that the value obtained from the expert validator of the content feasibility aspect was 98%, and the presentation feasibility aspect was 92.86%. The average value of material expert validation was 96.43% and had a very valid/very good category.

Table 6 shows that the value obtained from the media expert validator on the language and readability aspects was 98%, and the graphic feasibility aspect was 90.63%. The average value of media expert validation was 95.31% and had a very valid/very good category.

Table 7 shows that the value of the validator of the Guided Inquiry aspect of learning experts was 75%, and the integrated SPS aspect was 80%. The average value of learning expert validation was 77.50% and had a valid/good category.

The Mosiry e-module, validated by material, media, and learning experts, was then put to a small-scale field test. The small-scale field test involved two biology teachers and 30 students, resulting in the data listed in Tables 8 and 9.

Table 8: Limited-Scale Field Test for Biology Teacher Assessment Results Data.

No.	Assessment Aspect	Value	Category
1.	Media aspect	90.63%	Very valid
2.	Material aspect	93.75%	Very valid
3.	Language aspect	87.50%	Very valid
	Average	90.63%	Very valid

Table 8 shows that the teacher's assessment of the Mosiry e-module on the media aspect was 90.63%, the material aspect was 93.75%, and the language aspect was 87.50%. The teacher's average assessment of the Mosiry e-module is 90.63%, with a very valid/very good category.

Table 9: Limited-Scale Field Test for Biology Student Results Data.

No.	Assessment Aspect	Value	Category
1.	Media aspect	87.33%	Very valid
2.	Material aspect	89.33%	Very valid
3.	Language aspect	97.08%	Very valid
	Average	91.25%	Very valid

Table 9 shows that the students' assessment of the Mosiry e-module on the media aspect was 87.33%, the material aspect was 88.96%, and the language aspect was 89.33%. The average student assessment of the Mosiry e-module was 91.25%, with a very valid/very good category.

The validated Mosiry e-module was tested in a wide field by involving the module in learning activities and distributing response questionnaires to an experimental class of 41 students.

This questionnaire contained an assessment with a Likert scale from 1 to 4, as well as impressions and messages after using the Mosiry e-module. The results of the response questionnaire in the large group test are listed in Table 10.

Table 10 shows that students' responses to the Mosiry e-module on the media aspect were 90%, the material aspect was 91.34%, and the language aspect was 96.34%. The average student assessment of the Mosiry e-module was 92.56%, indicating a positive response. Learning using the Mosiry e-module received a very positive response from students; besides that, students also expected the development of a similar e-module for other biology materials.

In learning to use the Mosiry e-module a pre-test and post-test were conducted. The results of calculating the N-Gain Test pre-test/post-test values for the experimental and control class are listed in Table 11.

Table 10: Large-Scale Field Test Results Data.

No.	Assessment Aspect	Value	Category
1.	Media aspect	90%	Very valid
2.	Material aspect	91.34%	Very valid
3.	Language aspect	96.34%	Very valid
	Average	92.56%	Very valid

Table 11: N-Gain Value.

N-Gain Score Test Calculation Results				
Notes	**Experiment Class**		**Notes**	**Control Class**
	N-Gain score			N-Gain score
Average	56.6704		Average	-27.0064
Minimum	-25.00		Minimum	-131.58
Maximum	100.00		Maximum	31.76

Table 11 shows that the average value of the N-Gain score of the experimental class was 56.6704, with a minimum value of -25.00 and a maximum value of 100.00. It shows that there is an increase in the value of the pre-test/post-test. Meanwhile, the average value of the N-Gain score for the control class is -27.0064, with a minimum value of -131.58 and a maximum value of 31.76. It shows that there is a decrease in the value of the pretest-posttest. Based on the N-Gain value, applying the Mosiry e-module in biology learning could help improve the integrated SPS of students in the medium category. In biology learning, using the Mosiry e-module could improve students' integrated SPS. The increase in students' integrated SPS in each component was different. The improvement of students' integrated SPS in each component is listed in Table 12.

Table 12 shows an increase in the integrated SPS of students in the medium category in the experimental class and a decrease in the integrated SPS of students in the control class. In the control class, the students' ability to formulate hypotheses increased with an N-Gain score of 10.61, the ability to define variables decreased with an N-Gain score of -40.48, and the ability to define variables operationally decreased with an N-Gain score of -61.54, The experimental design ability decreased with the N-Gain score of -33.33, and the data presentation ability increased with an N-Gain score of 12.73. Overall, the average N-Gain score in the control class was -22.40.

In the experimental class, the students' ability to formulate hypotheses increased with an N-Gain score of 57.58, the ability to define variables increased with an N-Gain score of 37.29, the ability to define variables operationally increased with an N-Gain score of 67.35, and the ability to design experiments increased with an N-Gain score of 77.27. The ability to present data has increased with an N-Gain score of 63.64. Overall, the average N-Gain score in the control class was 60.62.

The product in a Guided Inquiry-based Mosiry e-module was distributed to teachers throughout Indonesia, with various representatives in each region. The distribution was done door-to-door for the Surakarta area for as many as two schools, and Google Forms for national distribution to as many as 12 schools.

Based on the dissemination that was carried out, an assessment was done by the respondents (Table 13).

Table 12: Table of N-Gain of SPS Components.

No.	Integrated SPS Component	Control Class		N-Gain Score	Experiment Class		N-Gain Score
		Pre	*Post*		*Pre*	*Post*	
1.	Formulation of hypothesis	34	41	10.61	34	72	57.58
2.	Variable definition	58	41	-40.48	41	63	37.29
3.	Operational definition of variables	61	37	-61.54	51	84	67.35
4.	Experimental design	67	56	-33.33	56	90	77.27
5.	Presentation of data	45	52	12.73	45	80	63.64
Average		52,97	45.30	-22.40	43.37	77.89	60.62
Conclusion		**Decrease**			**Increase (moderate)**		

Table 13: Dissemination Assessment.

No.	Assessment Aspect	Value	Category
1.	Media aspect	93.75%	Very valid
2.	Material aspect	93.30%	Very valid
3.	Language aspect	91.07%	Very valid
	Average	92.70%	Very valid

Table 13 shows that the teachers' response to the Mosiry e-module in the media aspect was 93.75%, the material aspect was 93.30%, and the language aspect was 91.07%. The average student assessment of the Mosiry e-module was 92.70%. It shows that the teachers' response to the Mosiry e-module was very positive.

Discussion

Mosiry E-Module Products Based on Guided Inquiry

The development of the Mosiry e-module was carried out in the four stages suggested by Thiagarajan et al. (1974) and Lestari (2018), namely 4-D (Define, Design, Develop and Disseminate). The developed e-module was an e-module that integrates the syntax of the Guided Inquiry learning model. The syntax of learning using the Guided Inquiry method, according to Kuhlthau, included: open, immerse, explore, identify, gather, create, share, and evaluate (Kuhlthau et al., 2012). These stages can be simplified into problem orientation, problem identification, formulating hypotheses, collecting data, analysing data, and drawing conclusions.

Identifying variables, formulating hypotheses, and processing and presenting data are investigative skills required in middle-level biology learning (Permendikbud, 2016). The Guided Inquiry syntax includes the investigation procedure in the student's integrated SPS. Therefore, the integrated SPS can be increased with Guided Inquiry-based learning (Suwardani et al., 2021).

The learning process using the Mosiry e-module was carried out by the stages of the Guided Inquiry activity based on opinions (Hidayati et al., 2021), namely, through working on the questions contained in the learning activities in the e-module. Work on the questions was done in groups, with the following stages: 1) orientation and identification of problems, with problems that connect the material with everyday life; 2) develop hypotheses, based on problem orientation; 3) collect and analyse data, through video links to material related to the problem; 4) communication, through presentation activities; and 5) making conclusions, making conclusions verbally and making posters. Through this activity, students are expected to be able to practice investigations and train students in integrated SPS.

Eligibility of Guided Inquiry-based Mosiry E-Module

The Mosiry e-module, based on Guided Inquiry, was tested for feasibility by expert validators and practitioners. The results of the media expert validator showed a percentage of 95.31% and had a very good category, the material expert validator showed a percentage of 96.43% and had a very good category, and the learning expert validator showed a percentage of 77.50% and had a decent category.

Based on the validation results, Mosiry's e-module practitioners had a very decent category, with a percentage of 90.63% for teachers and 90.63% for students. Overall, the Mosiry e-module based on Guided Inquiry had a feasibility of 91.25% with a very good/very valid category. In addition to the assessment as a percentage, the Mosiry e-module validation also contained suggestions and input. Before the large group test was carried out, suggestions and inputs from expert validators and practitioners were used to improve the Mosiry e-module.

Effectiveness of Guided Inquiry-based Mosiry E-Module

The effectiveness of the Mosiry e-module can be determined based on the pre-test/post-test values calculated using the N-Gain formula. Based on the N-Gain test, it is known that the N-Gain score of the control class was -27.0064, which means that learning that has not been taught in the investigation was ineffective in improving students' integrated SPS. In contrast, the experimental class had an N-Gain score of 56.6704, meaning that learning using Mosiry e-module was quite effective in improving students' integrated SPS.

Conclusion

The Guided Inquiry-based Mosiry e-module was categorised as good by expert validators and practitioners.

a. Media expert: 95.31% (very decent category)
b. Material expert: 96.43% (very decent category)
c. Learning expert: 77.50% (decent category)
d. Practitioners
    1) Teachers: 90.63% (very decent category)
    2) Students: 91.25% (very decent category)

Overall, the Mosiry e-module based on Guided Inquiry had a feasibility of 90.22% and had a very decent category. In the medium category, the Mosiry e-module based on Guided Inquiry was categorised as effective for improving students' integrated SPS. Based on the research conclusion, this study suggests that teachers could use guided inquiry-based e-modules to improve their students' integrated SPS, especially when dealing with abstract material. For future researchers, it is also suggested to distribute the e-module more widely.

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Authors:

Yanti Sulistyana is a Lecturer in Biology Education, Sebelas Maret University, Indonesia. Email: yantisulistyana16@gmail.com

Meti Indrowati is a Lecturer in Biology Education, Sebelas Maret University, Indonesia. Email: metiindrowati@staff.uns.ac.id

Joko Ariyanto is a Lecturer in Biology Education, Sebelas Maret University, Indonesia. Email: jokoariyanto@staff.uns.ac.id

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