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The Development of an Educational Statistics Module Based on a Guided Discovery Learning Model Oriented to Students' Statistical Literacy

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Abstract

The low statistical literacy of students encourages lecturers to develop lecture modules that can facilitate this ability. This study aims to determine how to create a feasible, practical, and effective educational statistics module and identify the feasibility, practicality, and effectiveness of the Guided Discovery Learning-based educational statistics module to facilitate students' statistical literacy. This type of research is Research and Development (R&D) with Plomp design with the stages of Preliminary Investigation, Design, Realization, and Evaluation. The trial subjects in this study consisted of two types, namely expert trial subjects and product trial subjects. The expert trial subjects were three lecturers of the Mathematics Education Department in one of The State University in Jakarta, while the product test subjects were seven mathematics education students in semester 4. Expert trial were conducted to assess the validity or feasibility of the products developed. The product trial was a limited trial to evaluate the practicality and effectiveness of the developed product. The results showed that the developed module met the feasible, very practical, and effective criteria. This research produces a module that can be used in statistics lectures to facilitate students' statistical literacy.

Keywords: Educational Statistics; Guided Discovery Learning Model; Module; Statistical Literacy

Abstrak

Rendahnya literasi statistika mahasiswa mendorong dosen untuk mengembangkan modul perkuliahan yang dapat memfasilitasi kemampuan tersebut. Penelitian ini bertujuan untuk mengetahui cara membuat modul statistika pendidikan yang layak, praktis, dan efektif serta mengetahui kelayakan, kepraktisan, dan keefektifan modul statistika pendidikan berbasis Guided Discovery Learning untuk memfasilitasi literasi statistik mahasiswa. Jenis penelitian ini adalah penelitian pengembangan atau Research and Development (R&D) dengan desain Plomp dengan tahapan Preliminary Investigation, Design, Realization, Evaluation. Subjek uji coba pada

penelitian ini terdiri dari dua jenis, yaitu subjek uji ahli dan subjek uji coba produk. Subjek uji ahli adalah tiga orang dosen Jurusan Pendidikan Matematika di salah satu Universitas Negeri di Jakarta, sedangkan subjek uji coba produk adalah tujuh orang mahasiswa pendidikan matematika semester 4. Uji coba ahli dilakukan untuk menilai kevalidan atau kelayakan produk yang dikembangkan. Uji coba produk merupakan uji coba terbatas untuk mengevaluasi kepraktisan dan keefektifan produk yang dikembangkan. Hasil penelitian menunjukkan bahwa modul yang dikembangkan memenuhi kriteria layak, sangat praktis dan efektif. Penelitian ini menghasilkan modul yang dapat digunakan dalam perkuliahan statistika untuk memfasilitasi literasi statistik mahasiswa.

Kata Kunci: Literasi Statistik; Model Guided Discovery Learning; Modul; Statistika Pendidikan

Introduction

Statistics is one of the subjects that students in higher education must study. Statistics is a branch of mathematics whose discussion focuses on the collection, processing, organization, presentation, analysis, and interpretation of several numbers to draw conclusions based on the results of data analysis (Aron, 2014; Kadir, 2015). Statistics is vital to learn because, throughout life, the results of research and statistical analysis will affect human life; one is inevitably faced with the necessity to read and interpret the results of statistical analysis, conduct research, and for future career development (Tokunaga, 2016).

One of the essential abilities that a person must have in learning statistics is statistical literacy. According to Wallman (1993), statistical literacy is the ability to understand and critically evaluate statistical results in everyday life and appreciate the contribution that statistical thinking can make in making decisions both publicly and personally as well as professionally and personally. Ben-Zvi & Garfiled (2005) revealed that someone with good statistical literacy could understand statistical information and research results, organize and present data, work with different data representations, and understand concepts, vocabulary, and statistical symbols. Statistical literacy has an impact on future decision-making (Andriatna, Kurniawati, & Wulandari, 2021a). Students must be statistically literate due to technological advancements that enable the quick dissemination of data-based information (Kurnia, Lowrie, & Patahuddin, 2024). The results of previous studies show that students' statistical literacy is essential.

Moreover, the scholars stated that statistical literacy still needs to be improved. Pamungkas & Khaerunnisa; (2020) revealed that the average statistical literacy of students only reaches 58.68 out of 100. In line with the results of previous studies conducted by researchers Hafiz & Nur Atiqoh (2023), the average statistical literacy of students is only 51.94 out of 100, with the lowest average component

being the ability to ask critical questions at 42.63. The results of interviews with lecturers teaching educational statistics revealed that students' statistical literacy still needed to improve. The results of the midterm exam for the educational statistics course reflect this, with an average score of only 51. The same thing was also revealed Yotongyos, M., Traiwichitkhun, D., & Kaemkate (2015) that students' statistical literacy, namely the components of reading skills, statistical knowledge, mathematical knowledge, context knowledge, and skills to evaluate information through critical questions are still low and must be explored more deeply. This is also supported by the results of research Jaehong, Gundegmaa, & Youngju (2020) which revealed that 70% of the research subjects were unable to achieve statistical literacy levels 3 and 4. Therefore, it is necessary to improve statistical literacy, including by learning statistics.

According to (Novita & Fatkhurahman, 2023), several factors influence statistical literacy, including the role of lecturers, anxiety levels, the ability to learn and use technology in learning statistics, and critical thinking skills. In addition, Carmichael, Watson, & Hay (2009) stated that two factors influence statistical literacy, namely situational factors and individual factors. Situational factors consist of pedagogical practices, the social climate of the classroom, and the classroom management strategies used by teachers. Individual factors are interest in mathematics is associated with students' prior knowledge their competency-based beliefs and their age. the role factor of lecturers indicates that lecturers must develop learning materials with specific learning models to facilitate students' statistical literacy.

Furthermore, some recommended statistics learning reforms (Ben-Zvi & Garfiled, 2005;Zieffler, Garfield, & Fry, 2018) include implementing learning with various active learning models, using alternative teaching materials, and using technology. However, the learning process of statistics in higher education has not been as expected. According to (Koparan, 2015;Astuti, Dwi & Prabowo, 2020), there are problems with learning statistics, including lecturers who are inefficient in conducting learning and do not use relevant materials and resources as needed in learning. This condition indicates that lecturers must improve their pedagogical and professional competencies, including how to teach statistics and be able to develop interactive teaching materials according to Course Learning Outcomes (CLO), consider student center learning models, and aspects of technology utilization so that statistics learning objectives are achieved.

One recommended teaching material is Guided Discovery Learning (GDL) based teaching materials. Some research on teaching method and material based on guided discovery learning has been conducted, including research Hakim &

Setyaningrum, (2024) stated that the integration of Realistic Mathematics Education and Guided Discovery Methods, supported by Quizizz, significantly improves students' statistical literacy. In line with previous study, Hariyanti & Wutsqa, (2020) which is stated that the module developed using the guided discovery learning model effectively develops students' statistical literacy in junior high school. Another scholar Lu'luilmaknun, U & Wutsqa (2018) stated that this learning is effective in increasing learning independence. Moreover, Nurhayani, Rosnawati, & Amimah (2020) revealed that Guided Discovery Learning can be applied to optimize students' interest in mathematics learning. In addition, (Simamora, Saragih, & Hasratuddin, 2018;Putra & Syarifuddin, 2018; Asri, Noer, & Haenillah, 2017) revealed that GDL-based teaching materials could improve problem-solving skills, concept understanding, reasoning, and mathematical critical thinking. Study on the development of educational statistics modules to facilitate the statistical literacy of higher education students has not been widely carried out. In this study, the researcher aimed to detail both the development process and the outcomes of an Educational Statistics Module that utilizes the Guided Discovery Learning Model, focusing on facilitating Statistical Literacy. Additionally, the study aimed to assess the quality of the module regarding its validation, practicality, and effectiveness, with the hope that it would serve as a viable alternative learning resource.

Method

This type of research is development research or Research and Development (R&D) because this research produced a module for statistical learning. (Gall, Gall, & Borg, 2003) stated that educational research and development (R&D) is used to develop and validate educational products. This process involves studying relevant research findings, creating the product based on the findings, field testing it in the intended setting, and revising it to address any issues found during testing. The goal is to ensure that the product meets its defined objectives. The research design used in this study was developed by Plomp (1997) and consists of five stages: Preliminary Investigation, Design, Realization, Evaluation, and Dissemination. However, due to limited research time, the researchers only used four stages: Preliminary Investigation, Design, Realization, and Evaluation. The stages of research with the Plomp model are described by the following flowchart (Iriani, Anisah, Luthfiana, Maknun, & Dewi, 2023).

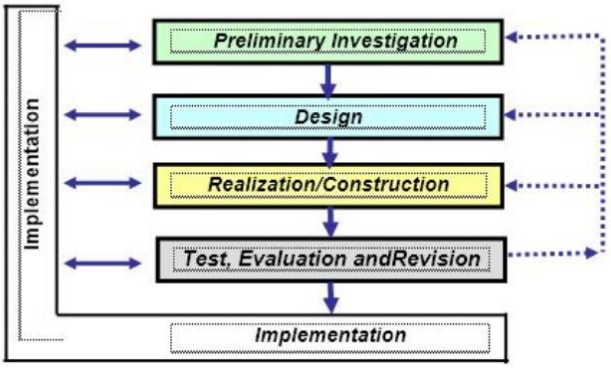

Figure 1. Flowchart of Design Research Stages with Plomp Model

The resulting product is an Educational Statistics module based on Guided Discovery Learning designed to facilitate students' statistical literacy. The module is intended for students studying Statistics Education. The module's content focuses on the concept of central tendency for individual and grouped data. The target of the module is students who are studying Statistics Education. The material used in the development of the module is the size of the centralization or central tendency of single data and group data.

Researchers identify the information needed to develop the module at the preliminary investigation design. The information collected includes information about the theory supporting module development, information about the Merdeka Learning Curriculum (MBKM) curriculum, especially the Program Learning Outcomes (PLO) of the Department, Course Learning Outcomes (CLO) and Sub-CLO, student characteristics, and Educational Statistics lecture materials. In addition to collecting this information, researchers conducted interviews with lecturers who had taught Educational Statistics courses to complement the data generated at this stage. Researchers collected data on material analysis and student learning outcomes, including students' statistical literacy levels. The interview data and other data that had been collected previously were then analyzed to get the information that was really needed in developing the module. Moreover, researchers reviewed the theory of the guided discovery learning model and attempted to analyze which stages in the model could facilitate students' statistical literacy.

The next stage is the Design stage. At this stage, the researchers designed the Statistics Education module. In addition, researchers also designed all research instruments used to identify the feasibility and readability of the module as well as

student responses to the developed module. The next stage is the Realization stage. At this stage, researchers produce module designs and all research instruments that will be used to validate the module. The module produced at this stage is called Prototype I. The last stage in this research is the Evaluation stage. At this stage, the researchers conducted two activities: expert validation of the developed module and a limited trial. The limited trial asked seven students to use the developed product and then asked them to fill out a student response questionnaire.

The test subjects in this study consisted of two types, namely expert test subjects and product test subjects. The expert test subjects were three lecturers from the Mathematics Education Department in one of The State University in Jakarta. In contrast, the product test subjects were seven mathematics education students in semester 4. The expert test was conducted to assess the validity or feasibility of the product developed. The product trial was a limited trial to evaluate the practicality and effectiveness of the developed product.

The research instruments used in this study consisted of four types. The research instruments are structured interview guidelines to explore information on the needs to be developed in the module, and an expert validation sheet is used as a tool to identify the feasibility of the module. The expert validation sheet was created by referring to the theory of ideal module development in learning. A student response questionnaire sheet was used to measure the module practicality. A Mathematical literacy test developed by Hafiz & Nur Atiqoh (2023) was used to assess the effectiveness of the developed module. The aspects of statistical literacy tests are literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions.

The data analysis technique used was a percentage to calculate the feasibility of the module Sari & Suswanto (2019), and then the eligibility criteria were used, as shown in Table 1 below.

Table 1. Expert Validation Questionnaire Score Guidelines

Percentage	Qualification
33,3% - 55,5%	less feasible
55,6% - 77,8%	enough feasible
77,9% - 100%	feasible

Data obtained from student questionnaire instruments are processed using the percentage technique. The practicality of the module that has been developed was measured by the following criteria (Akbar, 2017).

Table 2. Module Practicality Score Guidelines

Interval	Category
$85{,}00\% < V_p < 100{,}00\%$	very practical
$70{,}00\% < V_p < 85{,}00\%$	practical
$50{,}00\% < V_p < 70{,}00\%$	less practical
$01{,}00\% < V_p < 50{,}00\%$	not practical

The analysis of module effectiveness is evaluated based on classical completeness, which involves comparing the post-test results against the minimum threshold required for a good performance in the course (Suhandri & Syahwela, 2024). The statistical literacy score should be more than or equal to 70.

Results

During the preliminary investigation stage, interviews with students revealed that statistics learning primarily involves lecturers delivering material via slides. Students do not receive a module handbook, and the teaching method is predominantly expository, leading to a teacher-centered learning approach. Based on these findings, developing an educational statistics module in the form of a student handbook for statistics courses is considered. This module will be designed using the Guided Discovery Learning model, aiming to guide students to discover concepts independently rather than having them provided by lecturers.

The researcher also collected data on material analysis and student learning outcomes, including students' level of statistical literacy. The results showed that many students still needed help with reading the information presented as component bar charts. Some students need to become more adept at conducting inferential analysis in the Educational Statistics course. Interview data and other data that had been collected previously were then analyzed to obtain information that was needed in developing the module.

At the design stage, researchers determine the learning objectives written in the module. The next stage is the preparation of an outline of the contents of the draft module based on the arrangement starting from the front page cover, preface, table of contents, Course Learning Outcomes (CLO) and Sub-CLO, instructions for using the module, concept map, material mean, median, mode of single and group data (equipped with evaluation and data analysis exercises with Microsoft Excel and/or Statistical Package for the Social Sciences/SPSS), quartile material, deciles, and percentiles of single and group data (equipped with evaluation of data analysis

exercises with Microsoft Excel and/or SPSS), summary, answer key, scoring guidelines, glossary, references and author profile.

The flow of material explanation in this module uses the characteristics of the stages of the Guided Discovery Learning model. These stages include stimulation, problem statement, data collecting, data processing, verification, and generalization. The flow of the presentation of learning stages will involve students thinking more critically and finding their concepts to make them more interactive in learning. In addition, the teaching materials are equipped with data analysis practices with Microsoft Excel and SPSS application software. In addition to students having good mastery of concepts and statistical literacy, they are also expected to have skills in analyzing data with the help of software.

At the realization stage, researchers designed the front cover of the module, which consisted of the module title, material description, and module target, namely students, year of manufacture, and author's name. The module cover image is shown in Figure 1.

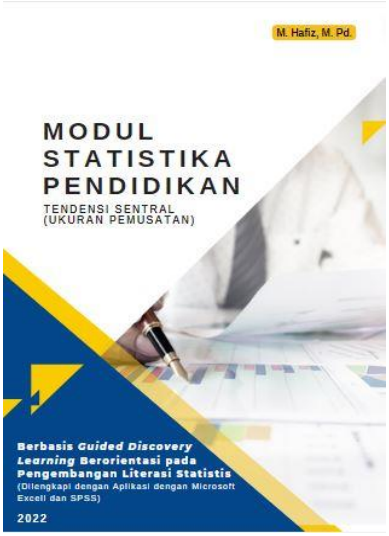

Figure 1. Front Cover Design of Module

This module employs the Guided Discovery Learning model, emphasizing constructivist learning. The structure of the learning activities in the module follows the stages outlined in the model, as illustrated in Figure 2.

Figure 2. Stages of Guided Discovery Learning on Module

The evaluation developed in the module is an evaluation in the form of multiple-choice questions as shown in Figure 3 and data analysis practice questions with Microsoft Excel and SPSS applications as shown in Figure 4.

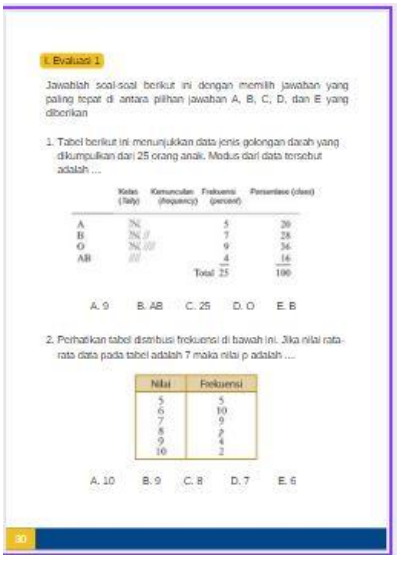

Figure 3. Example of Learning Activity Evaluation

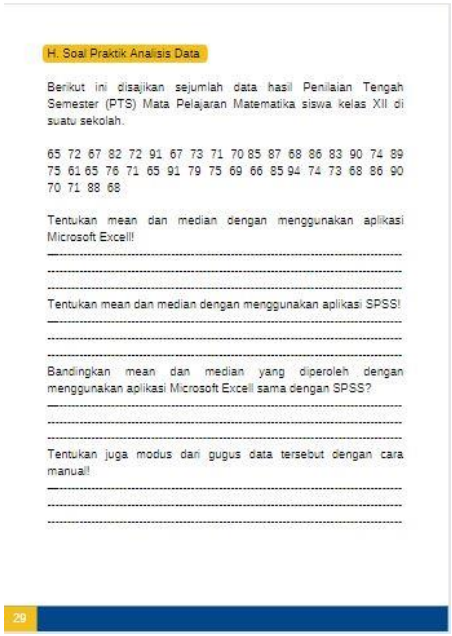

Figure 4. Example of Data Analysis Practice Question

Researchers also drafted expert validation and student response questionnaire instruments at the realization stage. The assessment items developed by the assessment refer to the module development theory.

The last stage is the evaluation stage. This stage consists of two phases that must be carried out hierarchically. The first is the module validation phase, which experts do to determine the feasibility or validity of the module produced. The expert validation process is carried out by mathematics education lecturers experienced in teaching educational statistics courses and developing modules. If there is a revision, the module is revised according to the validator's suggestion. Expert validation is carried out using a questionnaire instrument with a Likert scale whose score range is 1 to 3. Score three indicates a good response, two is sufficient, and one is less. The results of The Expert Validation of the Module are shown in Table 3.

Table 3. Results of Expert Validation of the Module

No.	Aspect	Percentage (%)	Criteria
1	Material Scope	88,89 %	feasible
2	Indonesian Language Rule	96,29 %	feasible
3	Presentation Technique	88,89 %	feasible
4	Model Guided Discovery Learning	86,11 %	feasible
5	Learning Objectives	83,33 %	feasible
6	Learning Assessment	83,33 %	feasible

From the results of expert validation of the material, it can be concluded that the module developed is in the feasible category.

Second, the module's limited trial phase. The module conducted a limited trial is a revised module that has been validated by experts have validated. The limited trial was conducted with a thorough and meticulous methodology, ensuring the validity of the results. Several students were taken using a purposive sampling technique; namely, the sample of test subjects was taken based on the research objectives and specific considerations set by the researcher (Sugiyono, 2016). Students were asked to fill out a questionnaire with a Likert scale with a score range of 1 to 3. A score of three indicates a good response; two is sufficient, and one is less. The results of the limited trial of the module are shown in Table 4.

Table 4. Results of The Student Response Questionnaire to the Module

No.	Aspect	Percentage (%)	Criteria
1	Material Scope	96,29 %	very practical
2	Indonesian Language Rule	96,29 %	very practical
3	Presentation Technique	94,33 %	very practical
4	Model Guided Discovery Learning	94,11 %	very practical
5	Learning Objectives	96,29 %	very practical
6	Learning Assessment	96,29 %	very practical

From the results of the student response questionnaire to the developed module, the module meets the criteria of practicality. The results of the limited trial questionnaire response by students were used as a basis for researchers to make revisions so that the product quality was better-called prototype II.

Third, the student statistical literacy test phase. The results of the statistical literacy test conducted on seven students after students used the developed educational statistics module are presented in Table 5 as follows.

Table 5. Students' Statistical Literacy Score

No.	Subject	Ideal Score	Statistical Literacy Score
1	Student 1	100	85
2	Student 2	100	84
3	Student 3	100	80
4	Student 4	100	62
5	Student 5	100	82
6	Student 6	100	78
7	Student 7	100	70
Average Score			77,29

After students had used the developed product, the average score for students' statistical literacy was found to be 77.29 according to the table 5. The score of statistical literacy based on its indicators is 85,71 for literacy skills, 74,29 for statistical knowledge, 72,14 for mathematical knowledge, 84,29 for context knowledge, and 70 for critical questions. The following figures are questions and sample student responses measuring mathematical and statistical knowledge.

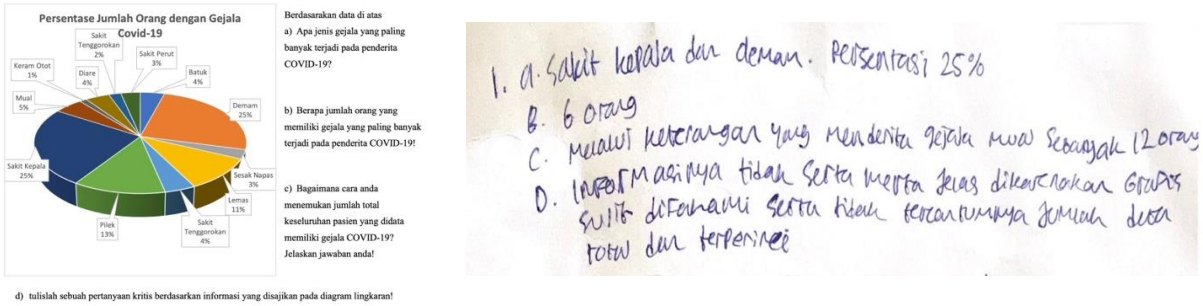

Figure 5. Question and Student's Response to Mathematical and Statistical Knowledge

Figure 5 shows that the student could not answer questions 1b, 1c, and 1d because he didn't understand ratio and proportion concepts and bar chart concepts, which affects the average statistical literacy score.

However, table 5 showed that 6 of 7 or 86% of students have a statistical literacy score greater than or equal to 70. Based on the university's criteria for the course value falling within the range of 70-79 being considered good, it can be concluded that the students' statistical literacy is in the excellent category. This indicates that the Guided Discovery Learning-based Educational Statistics module, oriented towards Statistical Literacy, meets the effective criteria. The documentation of limited trial activities is presented in Figure 6.

Figure 6. Documentation of Limited Trial of Module

Discussion

This educational statistics module development research produces products with feasible, very practical, and effective categories. The module developed can be recommended as one of the educational statistics modules using the Guided Discovery Learning model that can sharpen students' statistical literacy. This study's results align with research conducted by Maryati (2021) with the title "Module Development Based on Increasing Students' Statistical Literacy." The results showed that the teaching materials produced were valid with high categories, practical, effective, and feasible. Furthermore, this study in line with research conducted by Yulindra, Swastika, Negara, Setyaningsih, & Nurcahyo, (2023) stated that statistical literacy-based e-module on junior high school students' statistical content in class VIII is deemed appropriate for use in math classes and can serve as a resource for independent study by students.

Students' responses to teaching materials were very enthusiastic when they worked on data analysis questions with the help of Microsoft Excel and SPSS software applications. This aligns with the research results Nu'man (2019) titled "Development of Teaching Materials for Mathematics Education Research Statistics." The results showed that the teaching materials produced were valid with moderate categories, and students' responses to the use of teaching materials were delighted and enthusiastic about the use of teaching materials produced in development research.

From expert validation, it is known that aspect learning objectives have the lowest percentage because it did not appear in the module that students are analyzing activities in the learning process because they are too guided. Another lowest aspect is the learning assessment because there are no HOTS questions in the module. The average statistical literacy of students is only 77.29 because most students need help to answer the questions that test mathematical and statistical knowledge, even though statistical literacy is the ability to understand and interpret statistical symbols (Andriatna, Kurniawati, & Wulandari, 2021). Moreover, students still need help to construct critical questions based on the statistical problem given.

The study's results may be difficult to generalize to a broader population due to sample limitations and the context of the study. Due to time constraints, the method used in this study did not reach the implementation stage. In addition, to test the effect of the developed module on statistical literacy, quasi-experimental research can be conducted for future research. This study can further determine the effect of module provision on statistical literacy.

Conclusion

The Educational Statistics Module based on Guided Discovery Learning oriented to Statistical Literacy in this study was developed using the Plomp model with the stages of Preliminary investigation, Design, Realization, and Evaluation. The Educational Statistics module based on Guided Discovery Learning oriented to Statistical Literacy developed in this study meets the category of feasible, very practical, and effective use by students in the Statistics Education lecture. The Educational Statistics module based on Guided Discovery Learning oriented to Statistical Literacy developed in this study is effective in engaging students in Statistics Education lecture. The suggestion for further study is that future researchers can examine the effect of using modules associated with attitudinal aspects.

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