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Development of Project-Based E-Module to Facilitate Student's Mathematics Collaboration and Communication in Boarding School

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Abstract

Technological advances in mathematics education emphasise the importance of students having good mathematical collaboration and communication skills. However, the use of electronic-based teaching devices that support this is still rarely found, especially in Islamic boarding schools. This research aims to develop teaching materials in the form of project-based e-modules to facilitate junior high school students' mathematical collaboration and communication skills for use in mathematics learning. This type of research is developed using the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The subjects of this research were students in class VIII-A Al-Izzah IIBS Batu in the Islamic boarding school curriculum. Data collection techniques include unstructured observation and interviews. Data collection instruments used expert validation sheets, e-module reflection sheets, and post-tests. The development of this learning media has been proven to be valid and practical, with an average percentage of validity of 95.86% and practicality of 93.33%. Apart from that, Project-based e-modules can support students in communicating well so that collaboration is formed in teams that can respect differences of opinion and be responsible for their contributions. Based on the results obtained, the project-based e-module is valid and practical in facilitating Islamic boarding school students' mathematical collaboration and communication skills in mathematics learning statistics material.

Keywords: Collaboration skill; Communication skill; E-module; Project-based.

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Abstrak

Kemajuan teknologi dalam pendidikan matematika menekankan pentingnya siswa memiliki keterampilan kolaborasi dan komunikasi matematis yang baik. Namun, penggunaan perangkat ajar berbasis elektronik yang mendukung hal ini masih jarang dijumpai khususnya pada pondok pesantren. Penelitian ini bertujuan untuk mengembangkan bahan ajar berupa e-modul berbasis proyek untuk memfasilitasi kemampuan kolaborasi dan komunikasi matematis siswa SMP untuk digunakan dalam pembelajaran matematika pada. Jenis penelitian ini adalah pengembangan menggunakan metode Research and Development (R&D) dengan model ADDIE (Analysis, Design, Development, Implementation, Evaluation). Subjek penelitian ini adalah siswa kelas VIII-A Al-Izzah IIBS Batu pada kurikulum pondok pesantren. Teknik pengumpulan data berupa observasi dan wawancara secara tidak terstruktur. Instrumen pengumpulan data menggunakan lembar validasi ahli, lembar refleksi e-modul, serta post-test. Pengembangan media pembelajaran ini terbukti valid dan praktis, dengan persentase rata-rata validitas 95,86% dan praktisitas 93,33%. Selain itu, e-modul berbasis proyek dapat mendukung siswa dalam berkomunikasi yang baik sehingga terbentuk kolaborasi dalam tim yang dapat menghargai perbedaan pendapat serta bertanggungjawab atas kontribusi mereka. Berdasarkan hasil yang diperoleh, maka e-modul berbasis proyek valid dan praktis dalam memfasilitasi kemampuan kolaborasi dan komunikasi matematis siswa pondok pesantren pada pembelajaran matematika materi statistika.

INTRODUCTION

Entering the 21st century, the realm of education plays a significant role, considering rapid advancements in science and technology (Chen et al., 2023). In this context, educators are mandated to possess expertise in technology to foster student's thirst for knowledge (Arief et al., 2023). Soleman et al. (2020) assert that with the current industrial revolution, there is a need for innovation in the field of education, especially in the Islamic boarding school curriculum. This is because the Islamic boarding school curriculum tends to focus on religious learning and developing students' morals, so students need to be given facilities to develop their academic skills (Zhao et al., 2022). This era necessitates digital learning materials that enhance twenty-first-century competencies, such as integrating communication and collaboration proficiencies (Engelbrecht & Oates, 2022).

Collaboration and communication skills in mathematics can enhance competencies in the twenty-first century (Movshovitz-Hadar et al., 2023). Collaborative capacity manifests as a manifestation of a collective effort between two or more individuals to attain a mutually agreed-upon objective (Aghakhani et al., 2023). Indicators of mathematical collaboration encompass 1) cooperating and contributing within groups, 2) appreciating divergent viewpoints for the attainment of shared objectives, and 3) assuming accountability (Trilling & Fadel, 2009). When engaging in collaboration, students must also possess effective communication proficiencies (Lunenburg, 2010).

Mathematical discourse refers to the proficiency of students in constructing and elucidating a mathematical phenomenon utilising visual aids such as graphs and tables (Danuri & Choirunisa, 2023). An individual who possesses commendable communication abilities is someone who can effectively convey their notions to others (Stoehr, 2019). LACOE (Los Angeles County Office of Education) asserts that mathematical communication encompasses written communication as well as oral or verbal communication (Tampubolon et al., 2021). There are also discernible indicators of mathematical communication, specifically, 1) translating cogitations into mathematical vernacular; 2) employing skills to peruse, construe, and appraise mathematical notions; 3) employing mathematical ideas to formulate compelling justifications (Planas et al., 2004).

To compete on a global scale, students, particularly those in boarding

schools, necessitate 21st-century competencies; hence, mathematical collaboration and communication skills are of paramount importance (Chen et al., 2023). Nevertheless, the implementation of mathematical pedagogical models in boarding schools remains conventional in practice (Waswa & Al-Kassab, 2023). This assertion is corroborated in research (Hernandez-Martinez et al., 2023) that elucidates how mathematics learning inadequately affords students opportunities to actively engage in discussions and collaborate. The profusion of subjects in the boarding school's curriculum poses challenges for students in honing their mathematical proficiencies (Ramdhani et al., 2021).

Based on observations and unstructured interviews at Al-Izzah IIBS (International Islamic Boarding School) Batu, it is known that the learning characteristics use standard Islamic boarding school rules, which also prohibit the use of electronic devices in the form of cell phones both in the school and dormitory environments. However, students are allowed to use laptops in the learning process if needed. Data was also obtained regarding current mathematics learning, which still has minimal group discussion activities and collaborative projects. This causes students to have less opportunity to develop their mathematical collaboration and communication skills.

Based on this, the field of mathematics education necessitates innovative approaches that can enhance Shiva's aptitude for collaborative and communicative mathematical endeavours (Hinojosa & Bonner, 2023). Project-based learning (PJBL) is a pedagogical approach centred around students, characterised by cooperation, interaction, and introspection within the context of real-world applications (Guo et al., 2020). Project-based learning can actively engage students in the classroom (Caridade, 2023). Consequently, the implementation of projects within collaborative learning environments effectively enhances proficiency in mathematical communication skills (Stoehr, 2019). Furthermore, there are project-based learning initiatives that can support collaboration and the development of mathematical communication capabilities, which can be packaged in modular teaching materials (Rochsun & Agustin, 2020).

The teaching module, as described by Merwe et al. (2020), is an autonomous educational resource that encompasses a series of structured learning experiences aimed at assisting learners in achieving their educational objectives. The incorporation of modules into the learning process can serve as an alternative approach for learners to solve problems. The key features of a teaching module include 1) clearly stated learning objectives, 2) knowledge acquisition, 3) promotion of active student engagement, 4) inclusion of assessment mechanisms, and 5) comprehensive coverage of subject matter and assignments (Hellmuth & Scholz, 2024). Teaching modules can be presented in the form of electronic modules (e-modules) utilising information and communication technologies. An e-module is defined as a computer-based learning medium that incorporates textual information, images, graphics, audio, animations, and/or videos into the learning process (Baruah & Kakati, 2020). According to Engelbrecht et al. (2020), project-based e-modules have demonstrated positive effects on student learning outcomes. Therefore, the utilisation of project-based e-modules can enhance students' awareness of the material being taught while also fostering active participation in the learning process, ultimately facilitating students' collaborative and communicative mathematical abilities

(Dewi & Lestari, 2020).

Several researchers have undertaken studies on the development of project-based e-modules for mathematical education. The research conducted by Dewi & Lestari, (2020) on the development of teaching tools revealed that students who utilised project-based e-modules achieved higher learning outcomes compared to students utilising traditional learning media. Similarly, the development of e-modules by Jayanti and Yunianta (2022) yielded valid, practical, and effective teaching materials for facilitating the comprehension of trigonometric concepts in mathematical education. Additionally, there was an observable improvement in the effectiveness of the teaching materials, as evidenced by the students' pre-test and post-test results. However, the previous research endeavours focused solely on enhancing understanding and learning outcomes without addressing the facilitation of collaborative and communicative mathematical capabilities. Hence, the distinctive aspect of this research lies in the project-based e-module, which serves as an innovative tool to foster student's collaborative and communicative mathematical skills. Therefore, further research on the development of this e-module is both valuable and worthwhile.

METHOD

This research involves the utilisation of Research and Development (R&D) approaches. The ADDIE (Analysis, Design, Development, Implementation, Evaluation) development framework was employed (Hu, 2023). The use of this type and model of development research aims to produce teaching materials in the form of project-based e-modules, which are focused on facilitating students' mathematical collaboration and communication skills which are arranged systematically. The product developed was then tested for feasibility using validity and tested to determine the extent to which the e-module could facilitate students' mathematical collaboration and communication skills in statistics material.

During the analysis phase, researchers scrutinised the requirements by conducting observations during the mathematical learning process and unstructured interviews with Al-Izzah IIBS Batu's 8th-grade math instructor. The analysis encompassed an examination of the curriculum and the materials to be employed in the e-module. The design phase entailed the creation of products, specifically the preparation of instructional materials and the development of the e-module design. The e-module product design was crafted using CorelDRAW X7 software. The design of the e-module was customised to align with predetermined materials and real-world conditions to ensure students' ease of comprehension. In the development phase, the pre-designed e-modules were subsequently reviewed by the supervising lecturer. Validation was then sought from four experts, including two academics and two practitioners. The feedback obtained from this validation process was utilised to refine the project-based e-module that had been developed. Subsequently, the e-module underwent experimental testing to gauge its efficacy in enhancing student's mathematical collaboration and communication skills. Finally, the researchers conducted evaluations based on post-test results administered to students, utilising qualitative data to gauge the quality and feasibility of the developed e-modules.

This research was conducted at Al-Izzah Batu Junior High School during the second semester of the 2023/2024 academic year. The participants in this study were the students of class VIII-A at Al-

Izzah IIBS Batu, totalling 28 students, of which 27 students were involved. The object of this study was a project-based e-module. The data collection techniques employed included observations and unstructured interviews. The data collection instruments utilised in this research included expert validation sheets, post-tests embedded in the e-modules, and student reflection sheets. The expert validation questionnaires were distributed to academic validators and practitioners. The post-tests and learning reflection sheets were administered to the students. The media validation questionnaires employed a Likert scale assessment, with the highest Likert scale value set at 4 (Strongly Agree) and the lowest at 1 (Strongly Disagree) (Lestari et al., 2022). The questionnaire results were converted into percentages and subsequently analysed based on the validation assessment criteria. Each aspect of the validation test questionnaire grid was scored in accordance with the provided guideline answers:

Table 1. Validation Assessment Criteria

Score (%)	Criteria
85 < P ≤ 100	Very Valid
70 < P ≤ 85	Valid
55 < P ≤ 70	Enough
40 < P ≤ 55	Invalid
P ≤ 40	Very Invalid

Analysis of Practicality. This examination is employed to ascertain the extent of the practicability of the e-module formulated in accordance with the declaration on the validation sheet of the utilisation section (practicality). The scale employed on the sheet is the Likert scale, which utilises the checklist technique. The ultimate outcomes of the subsequent declarations will be presented based on the practical criteria presented below (Chaisri et al., 2022).

Table 2. Practicality Criteria

Score (%)	Criteria
0 < x ≤ 20	Very Impractical
20 < x ≤ 40	Impractical
40 < x ≤ 60	Less Practical
60 < x ≤ 80	Practical
80 < x ≤ 100	Very Practical

The post-test for students involved posing several questions related to statistical material following the implementation of the e-module. This was done to assess the enhancement of student's mathematical communication skills. Meanwhile, reflection activities were carried out to determine the extent of collaboration in the learning process.

Scoring the outcome of the reflection as the value of the mathematical collaboration aspect through the utilisation of a Guttman scale evaluation reveals two possibilities, where "yes" corresponds to a value of one (1) and "no" corresponds to a value of zero (0) (Caridade, 2023). Subsequently, the results were converted into percentages and examined based on the criteria established by the Likert scale (Nindiasari et al., 2022). The evaluation rubric employed in this research for assessing mathematical communication skills is an adapted version derived from the work of (Firda et al., 2019). The grading rubrics are assessed based on the indicators of mathematical communication abilities and are also converted into percentages and analysed using the Likert scale, as depicted in the subsequent table.

Table 3. Likert Scale Score Percentage Criteria

Score (%)	Criteria
x ≤ 20	Very Less
20 < x ≤ 40	Not Enough
40 < x ≤ 60	Enough
60 < x ≤ 80	Good
x > 80	Very Good

The technique employed for data analysis in this study is qualitative descriptive analysis, which elucidates the

outcomes of project-based e-module development. The data collected from participants and validators is subsequently averaged to ascertain the quality and feasibility of project-based e-modules in fostering students' mathematical collaboration and communication skills pertaining to statistical materials.

RESULTS AND DISCUSSION

Results

This research utilises the ADDIE development model, which comprises five stages, specifically analysis, design, development, implementation, and evaluation.

Analysis

The outcomes of the analysis in the development of project-based e-modules are needs analysis, curriculum analysis, and media analysis. Needs analysis is executed by observation of the school to determine the issues associated with the learning process. The information obtained is as follows: 1) Mathematical learning tends to be traditional, which leads to a deficiency of student involvement in the learning process; 2) The lack of utilisation of additional teaching materials other than school package books; 3) Insufficient group discussions and collaborative projects because the learning tends to concentrate on comprehending mathematical concepts. 4) Students still lack good mathematical communication skills because the learning target is sufficient to reach the understanding stage without focusing on students explaining a mathematical problem. So, we need teaching materials that can facilitate students' mathematical collaboration and communication skills.

Curriculum analysis is conducted based on the modern boarding school cottage curriculum, which is integrated into teaching and learning activities and habituation activities by taking into account school indicators and class indicators that have been determined (Soleman et al., 2020). The result of this analysis is that there is no emphasis on aspects of student mathematical collaboration and communication, such as collaborative projects and practice questions that direct students to practice their mathematical communication. Apart from that, students only focus on learning at school when they are in the classroom. In fact, teachers are not allowed to give assignments to be done outside of class because students already have a schedule for their religious activities. Thus, the results of this analysis have an impact on students' mathematical collaboration and communication abilities, which are less facilitated, especially in statistics material.

Media analysis. Based on the analysis executed, the results show that the learning medium previously utilised tends only to motivate student learning and concentrate on aspects of understanding. As a result, project-based e-modules were developed to facilitate both mathematical abilities.

Design

The subsequent stage is the design of the product in the form of e-modules. This e-module is designed to facilitate students' mathematical collaboration and communication skills. Such goals are realised by the completeness and clarity of the materials and components contained therein. Collaboration is realised in the module worksheet as a group project. Then, the communication aspects are realised in the form of discussion sheets as well as post-test questions containing mathematical communication indicators. The post-test question was adopted from a study

conducted by Firda et al., (2019). Below is a flowchart of the student learning process using an e-module:

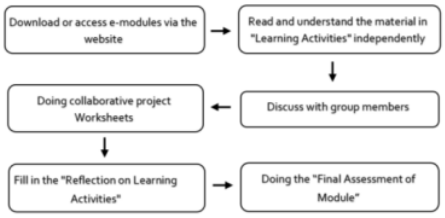


Figure 1. Student learning process

E-module reference. In developing the e-module, researchers search for and collect references from a variety of sources. Reference e-module views and images from freepik.com, background views from Canva, materials from YouTube, as well as previous researchers' teaching modules. There are also e-module designs created using the CorelDRAW X7 application. After the e-module is completed, it will be created in the form of a flipbook to facilitate reuse access.

Media strategies. The strategy is formulated as a basic framework of the e-module blueprint. The blueprint of this e-module comprises 1) Initial perspective/cover. This perspective contains the title, target class, material, identity of the compiler, and images characterizing the uploaded material. 2) The second perspective, namely the introduction. 3) Introduction, which encompasses a description and instructions for the utilization of the e-module. 4) RPP display (Learning Implementation Plan) corresponding to the 2013 curriculum. 5) Concept map statistical material. 6) Perspective the core, i.e. material, grouped project worksheets, and study reflections, as many as three times the meetings presented in "Study Activities 1,2, and 3". The first material is to know the data, and the second material is the presentation of the data, and the measure of data centralisation is the last material. 7) In the final assessment perspective of the module, there are two types of tests, namely double choice and description (post-test), that contain mathematical communication indicators. 8) Evaluation indicators of the final assessment work result of the module so that students can independently evaluate the results of the work on a multiple-choice question. 9) Cover. 10) Appendix, containing glossary, answer key, and scoring rubric. 10) Library list.

Figure 2. E-modul Cover

Figure 3. Display of E-Module Material

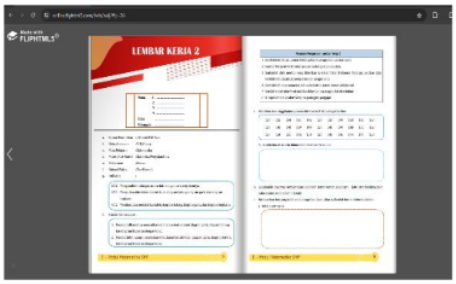


Figure 4. Collaborative Project Worksheets

Instrument blueprint of the validation sheet. The validation sheet of the e-

module comprises the validation of materials and media that are synthesised into one. Media validation has aspects of design, use (practicality), and consistency. For validation, the material includes content qualification aspects, linguistic feasibility aspects, presentation qualification aspects, project-based learning aspects, and mathematical collaboration and communication aspects. The validation instrument grid is attached to Table 4 as follows.

Table 4. Validation Instrumen Grid

Aspects and Indicators	Amount of Questions	Question Number
Media		
Design	3	1,2,3
Usage (Practicality)	3	4,5,6
Consistency	2	7,8
Material		
Content Qualification Aspects	5	9,10,11,12, 13
Linguistic Feasibility Aspects	3	14,15,16
Presentation Qualification Aspects	3	17,18,19
Project-Based Learning Aspects	2	20,21
Mathematical Collaboration Aspects (Worksheets and Reflections on E-Modules)	4	22,23,24,25
Mathematical Communication Aspects (Essay at the End of Module Assessment)	3	26,27,28

Based on the e-module grid in Table 4, on the validation sheet, there are 28 statements that need to be validated by experts. Among them is the Usage (Practicality) aspect, which consists of 3 questions. Where this aspect will be a reference for assessing the practicality of using e-modules.

Development

At this stage, e-modules that correspond to the strategies that were formulated at the design stage will be developed. The media used to develop the e-module, i.e. flipbook.

The steps in the e-module development stage are as follows: the researcher creates a display design for each of the components to be loaded in the e-module, then written in Microsoft Word, and finally made in pdf format. After that, the file is included on the flipbook website so that it is accessible using the internet and flexible for repeated use. Here is the link to the SMP statistics e-module: https://online.fliphtml5.com/ltvta/nalj/

Once developed and realised into an e-module, it was then validated by five validators: 3 validators from the lecturer in Mathematics Education at Muhammadiyah Malang University and two validators from mathematics teacher Al-Izzah IIBS Batu. The results of the e-module assessment by each validator can be seen in Table 5.

Table 5. Validator Assessment Results

Validator	Score	P (%)	Criteria
1	112	100	Very Valid
2	110	98,2	Very Valid
3	102	91	Very Valid
4	107	95,5	Very Valid
5	106	94,6	Very Valid
P Average =		95,86	Very Valid

Table 5 reveals an average percentage of 95.86% with the classification of "Very Valid," thereby affirming the excellence and suitability of the e-modules as instructional materials for mathematics learning. The validity analysis findings are further supported by the research conducted by Ulfa et al., (2023), where a similar percentage under the "Very Valid" category was obtained during the media validation phase, thereby confirming the worthiness of the e-modules developed for this project.

Practicality analysis. This analysis is conducted based on the practicality

aspect as assessed by the experts on the validation sheet. The practicality analysis results are presented in Table 6.

Table 6. Practicality Aspect Score

Statement	Average Score	P (%)
Ease of use	3,8	95
Flexible to use	3,8	95
Clarity of instructions for use	3,6	90
	P Average =	93,33

Information: Maximum score = 4

Table 6 demonstrates an average percentage of 93.33% for the practicality scores of the e-modules with the classification of "Very Practical". Hence, it can be concluded that the e-modules are highly practical for utilization in mathematical learning.

After the validation process is carried out, the e-module is improved according to the suggestions given by the validator to produce an electronic teaching module that is ready to be used in learning.

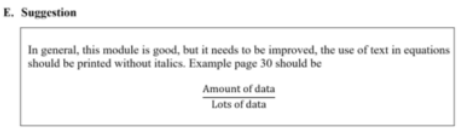


Figure 5. Validator Suggestion/Comment

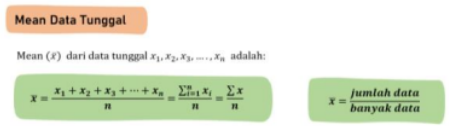


Figure 6. Before Revision

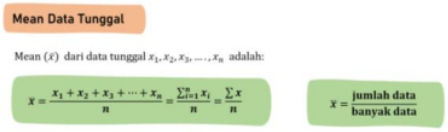


Figure 7. After Revision

Implementation

In the implementation phase, e-modules were trialed directly on a group of 27 students from the VIII-A Al-Izzah IIBS Batu class. Since the use of mobile phones is prohibited in this educational institution and the utilization of laptops is restricted, the completion of group project worksheets is carried out with each group utilizing only one laptop. Consequently, the work process must alternate in accordance with the division of tasks.

Figure 8. Implementation of E-Module

This circumstance also impacts the situation when students desire to review the content on the e-module. To accomplish this, students must take turns utilising the laptop, emphasising the necessity for effective collaboration. Subsequently, students are required to complete individual reflection sheets, which are handwritten on paper, as they are unable to operate laptops simultaneously.

The final stage of the implementation process involves post-test work. This section is carried out individually, with each sitting group of students having access to a laptop to read post-test questions. As the process progresses, a timer is displayed on the projector screen, serving as an indication of the remaining working time.

Figure 9. Working on Post-Test

At this stage, students work on the "Final Module Assessment", which contains 20 multiple-choice and three descriptions (post-test) with a duration of 50 minutes with the aim of testing students' understanding of statistical material. Post-test work has problems, one of which is the limited time available because the previous subjects used more learning time than they should. Apart from that, students also tend to focus more on working on multiple choice questions first, so the remaining time for working on the description (post-test) is very limited.

Evaluation

The concluding stage in the development of project-based e-modules is evaluation of the facilitation of students' mathematical collaboration and communication skills in statistics material.

Analysis of mathematical collaboration aspects. This analysis is performed to determine the outcomes of student's mathematical collaboration based on their learning reflections during meetings 1, 2, and 3. The learning reflections include questions that are tailored to the indicators of mathematical collaboration.

Tabel 7. Collaboration Score for Each Meeting

Reflection	Score	P (%)	Criteria
1	71	87,6	Very Good
2	78	96,2	Very Good
3	80	98,8	Very Good
P Average =		94,2	Very Good

Information: Maximum Score = 81

Table 7 exhibits an average percentage of 94.2% with the classification of "Verry Good", signifying that the e-modules excel in facilitating the aspects of student mathematical collaboration.

Post-test analysis. This analysis is conducted to assess the facilitation of mathematical communication aspects through the usage of e-modules. During this stage, students engage in the "Final Assessment Module," which comprises 20 multiple-choice questions and three descriptive questions (post-tests), which are adjusted to mathematical communication indicators.

Table 8. Communication Score of Each Number

Number	Average Score	Max Score	P (%)	Criteria
1	32,14	35	91,8	Very Good
2	27,14	30	90,5	Very Good
3	22,32	35	63,77	Good
P Average =			82	Very Good

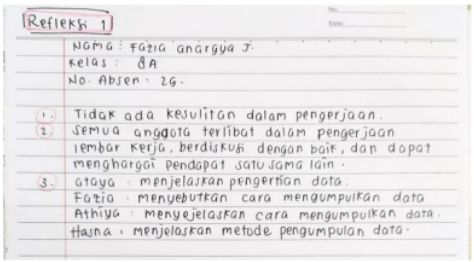
Table 8 demonstrates a mean proportion of 82% with the classification "Verry Good"; hence, e-modules are denoted as superlative in enabling facets of students' mathematical communication. Based on the findings presented in Tables 6 and 7, it can be inferred that project-centred electronic modules are efficacious in facilitating students' mathematical cooperation and communication skills.

Discussion

This research developed a project-based e-module in the form of a flipbook shape. The digitally flipped version of the printed flipbook was chosen due to its ability to not only facilitate digitally accessible educational resources but also enhance students' interactivity and interest in mathematical learning (Campbell & Yeo, 2023). Hence, project-based e-modules have the potential to enhance students' motivation to learn and foster active engagement in the learning process.

The developed e-module comprises statistical materials for 8th-grade students, discussion tasks, and collaborative project worksheets that can facilitate student collaboration. Through collaboration, students will inherently refine their communication skills (Villeneuve et al.,

2019). The e-module is tailored for teaching statistical materials in mathematics and consists of three sessions. Each session includes learning materials, discussion tasks, collaborative worksheets, and opportunities for students to reflect on their learning. These reflections enable students to not only assess their collaborative efforts but also identify any obstacles they encounter during the learning process.


Refleksi 1

NAMA : Fazia Anargya J.
Kelas : 8A
No. Absen : 26.

1. Tidak ada kesulitan dalam pengerjaan.
2. Semua anggota terlibat dalam pengerjaan lembar kerja, berdiskusi dengan baik, dan dapat menghargai pendapat satu sama lain.
3. Gtoya : menjelaskan pengertian data.
   Fazia : menyebutkan cara mengumpulkan data
   Athiya : menyejelaskan cara mengumpulkan data.
   Hasna : menjelaskan metode pengumpulan data.

Figure 10. Respondent's answer in Reflection 1

Figure 10 illustrates one of the respondents' responses to Reflection 1. Through this image, it becomes evident that students encounter no difficulties in comprehending statistical concepts when employing electronic modules. Furthermore, the collaboration among students while discussing and working on worksheets is commendable. This is evident in the third point, which delineates the division of tasks into groups.

When implemented in mathematics classes, the e-module received a positive response. Through collaborative projects, learning becomes non-traditional and places students at the forefront of the learning experience. In addition to positive feedback from students, the mathematics teacher at Al-Izzah IIBS Batu also expressed a favourable opinion regarding the e-module. The e-module received high ratings for its design, language, functionality, and educational materials, making it highly suitable for use in the learning process.

Furthermore, in addition to facilitating collaboration through group project worksheets, e-modules also enhance students' mathematical communication skills. This is evident in the discussion tasks conducted during each session. The e-module also includes a post-test section that assesses students' mathematical communication abilities.

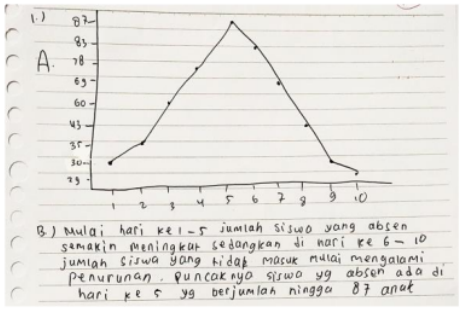


Figure 11. Students reflect thoughts into mathematical language.

Figure 11 demonstrates that students possess the ability to articulate their thoughts in mathematical language, as evidenced by the line diagram depicted in point a. Initially, students are provided with raw data, which they then transform into diagrams. Additionally, point b illustrates that students are capable of interpreting mathematical concepts and presenting them in the form of compelling arguments.

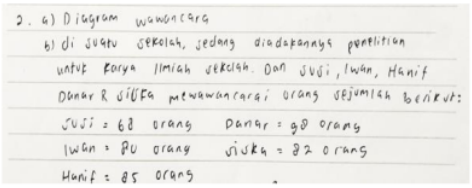

2. a) Diagram wawancara
b) di suatu sekolah, sedang diadakannya pemilihan untuk Karya Ilmiah sekolah. Dan Suci, Iwan, Hanif Dhanar & Sinta mewawancarai orang sejumlah berikut:
Suci = 68 orang Dhanar = 98 orang
Iwan = 80 orang Sinta = 82 orang
Hanif = 85 orang

Figure 12. Students make convincing arguments based on mathematical ideas.

Figure 12 shows that students could compose arguments based on a form of mathematical idea. At point A, students can create a title based on a diagram, and then at point b, students can explain it

into a story. This shows students have good written communication skills.

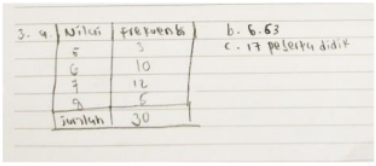


Figure 13. Students interpret mathematical ideas.

Figure 13 shows that students have the skills to read, interpret and evaluate mathematical ideas, with students first reflecting their thoughts in mathematical language. In point a, students are asked to present raw data in the form of a frequency table. In this case, students apply their reading and interpretation skills. Then, points b and c show that students have good abilities in evaluating mathematical ideas.

In addition to the post-assessment responses to assess students' written expression, their verbal interaction was also considered. By incorporating this electronic module offline, researchers can infer, based on their observations, that they effectively interact with each other. This is demonstrated by the utilisation of cooperative assignments in the educational setting. When students engage in dialogue and cooperate with the group, they certainly utilise effective interaction to achieve satisfactory project outcomes.

Drawing from this exposition, it can be deduced that the implementation of project-centered electronic modules can enhance mathematical interaction abilities and comprehension of statistical content effectively. This is consistent with studies indicating that project-centered electronic modules are efficiently utilised in mathematical education. Moreover, Danuri further emphasized that project-centred electronic modules could enhance students' mathematical interaction abilities. Hence, the innovation of this investigation lies in creating project-centered electronic modules that can facilitate students' mathematical cooperation and interaction abilities on secondary school statistical content.

To ensure accessibility, the project-based e-module can be accessed online through a website or downloaded in PDF format, allowing for offline usage. This flexibility and ease of access make the e-module highly convenient. Additionally, the e-module does not have any time restrictions, allowing for repeated usage.

Implications of Research

This study emphasizes the importance of establishing specific conditions between the researchers and the educational institution or subject of the study. These conditions serve as the foundation for conducting the study. Furthermore, this research contributes to the development of teaching materials in the form of project-based e-modules that facilitate students' collaboration and communication of statistical materials. The e-module also enables self-directed learning as it can be used repeatedly and is easily accessible.

Limitations

This study encountered limitations related to the use of devices as a learning medium, specifically the limited availability of laptops, with only one provided per group. Additionally, the lack of internet access in schools posed a challenge, requiring the e-modules to be transferred via flash drives to each laptop. However, these limitations did not hinder the researchers, as they were able to find effective solutions. It is important to note that this study is limited in its generalizability due to variations in the characteristics of the study subjects and research locations, which can influence the study's findings.

CONCLUSION

Based on the analysis of the research findings, it can be deduced that the developed project-centered electronic modules are valuable tools that enhance the learning process and foster students' mathematical collaboration and communication competencies. The electronic modules focused on statistical materials fulfill the criteria of validity, as evidenced by the average percentage of 95.86% obtained from the validators. Furthermore, these modules meet the criteria of practicality, with an average percentage of 93.33% obtained from the three usage statements on the validation sheet, thus categorizing them as "Very Practical." Moreover, the project-centered electronic modules effectively facilitate students' mathematical collaboration and communication skills, achieving an "Excellent" rating. Suggestions for future research involve further enhancing the electronic modules by considering various aspects especially in the Islamic boarding school curriculum.

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Development of Project-Based E-Module to Facilitate Student's Mathematics Collaboration and Communication in Boarding School

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