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# The STEM-based Mathematics Module Development to Improve Numerical Literacy and Learning Self-Directness of Fifth Graders

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**Abstract**

Modules are one of the teaching materials used to assist the learning process. This research developed a STEM-based mathematics module. This Research & Development (r&d) adopted the ADDIE method, consisting of five stages, starting from Analysis, Design, Development, Implementation dan Evaluation. The analysis phase begins by examining the demands for instructional materials. Followed by the Design stage, which entails defining objectives and materials, the Development stage, which entails making the design a reality, the Implementation stage, which entails determining the product's effectiveness, and the Evaluation stag. Collected the data with an interview, test, questionnaire, and observation. The number of respondents consisted of 37 learners in the academic year 2022/2023.The result showed that 1) the characteristics of the developed module had the focus to improve the numerical literacy and self-directedness of learners; 2) the module reliability was excellent with a very valid category; 3) The readability of the module was higher than 60% or categorized readable; 4) the module was practice proven with a percentage of 84% ; 5) and the module was effective and could influence the improvement of numerical literacy and learning self-directedness. Concluded that the STEM-based mathematics module development was effective to improve numerical literacy and learning self-directedness.

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## INTRODUCTION

Many factors determined successful learning. Susilawati (2020) showings that teaching material becomes an important factor in the learning process. Excellent teaching materials could motivate learners to study hard, improve their learning self-directedness, and improve other various competencies by learners (Nuryasana, 2020). One of the applicable teaching materials to train learners' self-directedness is a module.

Hamid (2017) showings that the module could anticipate limited-time learning. A module can also train the learners' self-directedness. Sucie (2021) Showingthat the module should have a certain basis. Stem is one of the instructional resources that promote student autonomy in learning. Carvalho (2022) showing that mathematics-module could encourage learners to be independent and active.

Not all module have excellent effects to improve various competencies of the learners. This issue leads to various problems, such as lower numerical literacy skills.Numerical literacy is an important component as stated in the Minimum Competence Assessment, AKM, the substitutive evaluation program of the national examination (Safitri, 2019). In light of the significance of numeracy skills as a component of the AKM, it is vital to take a variety of steps to enhance students' numeracy abilities, one of which is to increase their numeracy literacy

Dantes (2021) disclose that numerical literacy refers to the knowledge and skill to obtain, interpret, and communicate mathematics numbers and symbols in solving practical problems in a real-life context. Literacy is also useful to analyze the displayed information in the form of graphics, charts, tables.

Low numerical literacy skills of the learners were observable from the PISA test. The test showed that the numerical literacy skills of learners in Indonesia were low. Indonesia is ranked 73 out of 79 participating countries (Mccomas, 2018). The result showed the mathematics mean score was 379, lower than other small countries (Rastuti, 2021). The poor result of the PISA test should have received serious attention. All parties must struggle to improve the numerical literacy of learners by developing teaching materials or other aspects related to numerical skill improvement.

The statement about poor numerical literacy was also observable in the poorly applied teaching materials. The teaching materials could not support the numerical literacy skills of learners. Many aspects showed this problem, starting from the content material, question, and applied approach, Based on a review of the requirements for instructional materials. From the problems and the applied Government Rule Number 19 in the Year 2005, about the role of teachers, the teachers should have developed teaching materials (Sulistyosari, 2018). The teaching material development should also include mathematics teaching materials to improve the numerical literacy skills and the self-directedness of the learners. One of them is module implementation. Learners must be able to apply various numbers and symbols related to basic mathematics in solving mathematics practices in various daily life contexts. They must also be capable of analyzing the given information, in the forms of graphics, tables, and charts (Rakhmawati, 2022). They have to be capable of interpreting the analysis results to predict and decide independently. There are a number of ways that may be utilized to facilitate the production of instructional materials in the form of modules, including the stem approach.

Expected the mathematics development based on STEM - Science, Technology, Engineering, and Math on the materials about velocity, distance, and time could provide a real-life connection for the learners. Thus, learners would not merely study the numbers, symbols, and formulas. In this model, the researchers provided scientific, technological, engineering, and mathematics (STEM). Elements of science in the STEM curriculum will aid students in their mathematical studies of natural events,The use of technology by students to study mathematics is referred as as the technical element of stem, for students, using technology to address a variety of issues may be made simpler by engineering

concepts in STEM. The implementation of STEM for a module is important, moreover for mathematics learning. This implementation could improve the mathematics connectivity skills between a lesson and other lessons in the real-world context for the learners (Niam, 2021).

Based on research conducted by utami (2018) shows that the stem approach is very effective for use in learning mathematics. Sri (2021) found that the STEM approach could transform mathematics learning with a focus on numbers, symbols, and formulas into mathematics with real-world connections. Thus, the STEM approach could improve the numerical skills and self-directedness of the learners.

This research developed a STEM-based mathematics module to improve numerical

literacy and learning self-directedness. The implications of this research included the specific contribution to improving numerical literacy and self-directedness of learners; and in facilitating teachers to carry out the learning.

## METHODS

This Research & Development applied ADDIE design, consisting of five stages: analyzing, designing, developing, implementing, and evaluating. The following is the flow of Addie's research stages:

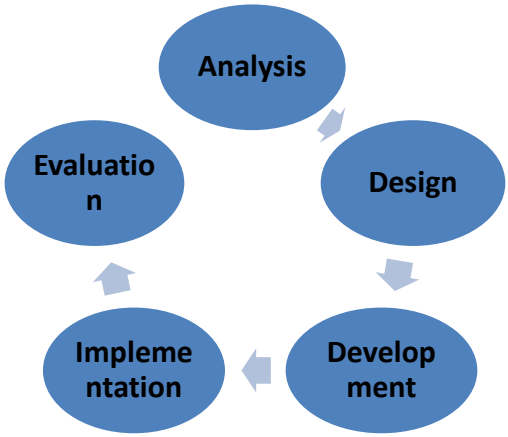
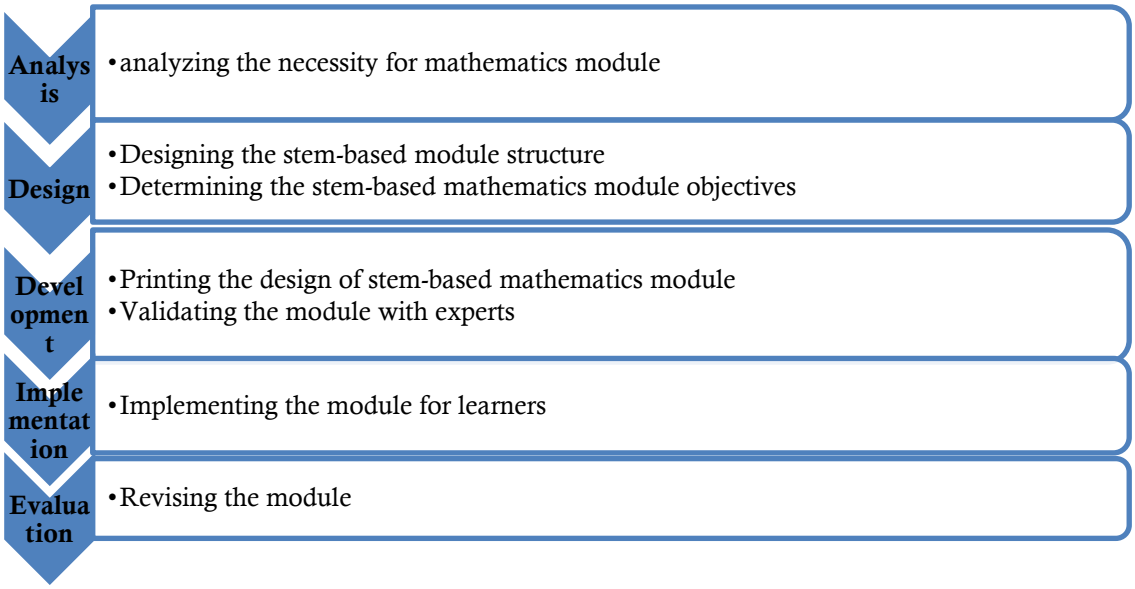



**Figure 1**. Desain ADDIE

Mabruri (2019) showing that the research stages with ADDIE design - analyzing, designing, developing, implementing, and evaluating - have clear and rational stages. The following is Addie's research scheme:



The analysis stage was about collecting information, starting from the teaching material necessity, core competence, basic competence, indicator, and challenge analysis. The stage also shared the required information. This research design facilitated the researchers to develop the STEM-based mathematics module. The designing stage consisted of determining the elements of STEM, designing the module structure, and arranging the module map. The mathematics module development stage realized the prearranged design into a product (Safitri, 2019). The final result was a module to test. The product of the R&D was a module that was ready to test. In the implementation stage, the researchers reviewed the STEM-based mathematics module by involving media, language, and material experts. This action was important. Ariani (2017) Showing that a developed teaching material should be examined by various field experts. Tested the module by involving the fifth graders in the research site. In this stage, the collected the data to measure the product effectiveness level. The product test design was one group pretest-posttest. After promoting the test, Implemented the product. In this process, the researchers would revise any shortcomings in the process. However, if did not find any shortcomings, the researchers would apply the product for further learning.

Collected the data through an interview, observation, and documentation (Fajar, 2021). The applied data collecting techniques were interview, test, questionnaire, and observation. The research subjects consisted of fifth graders of Public Primary School 1 and 2 Bangun. They were 37 learners with the given materials of speed, distance, and time in the academic year 2022/2023. Analyzed the data descriptively. The researchers classified all collected data. Stated the qualitative data with words while the qualitative data with numbers. The qualitative data was useful to provide and present figures. Then, the quantitative data was usefult o process the data from the observation sheet and the total score from the questionnaire. Also applied quantitative descriptive analysis by grouping the data based on the instruments, in the form of descriptive percentages. The applied quantitative data analysis included the validity of the STEM-based mathematics module, practicability analysis, reliability analysis, and effectiveness analysis.

## RESULTS AND DISCUSSION

### The Reliability of STEM-based Mathematics Module

The researchers validated the developed STEM-based mathematics module by involving experts. The researchers validated the early STEM-based mathematics module design by involving the media expert. The result showed that the developed product obtained a mean percentage of 92%, categorized as valid and applicable for small-scale learning. Mujib et al., (2020) also developed a STEM-based mathematics module. In their research, their product could reach a reliability percentage of 93%.

The STEM-based mathematics module design had various figures, adjusted-animated cartoons with materials about distance and time, and bright colors to attract learners. The next phase of the research was material expert validation to determine the material completeness, material accuracy, material update, and numerical literacy and self-directedness improvement.

The validation result of the module reached a percentage of 85%, categorized as valid and applicable for the learning. Puspaningtyas et al., (2021) also suggested that a module should be valid with an excellent reliability level. The researchers adjusted the given materials in the module to the daily life of the learners, by applying the STEM approach. The researchers also focused on improving the numerical literacy of the learners by providing various problems based on numerical literacy for the learners. After this phase, the researchers validated the module with a linguist or language expert to determine the relevance, clarity, and Indonesian grammatical accuracy of the module. The validation of the language expert obtained a percentage of 77%, categorized as valid and applicable for the learning. Niam et al., (2020)

also suggested that mathematics module development should have excellent validity in terms of language aspect. In their study, the percentage was 92%.

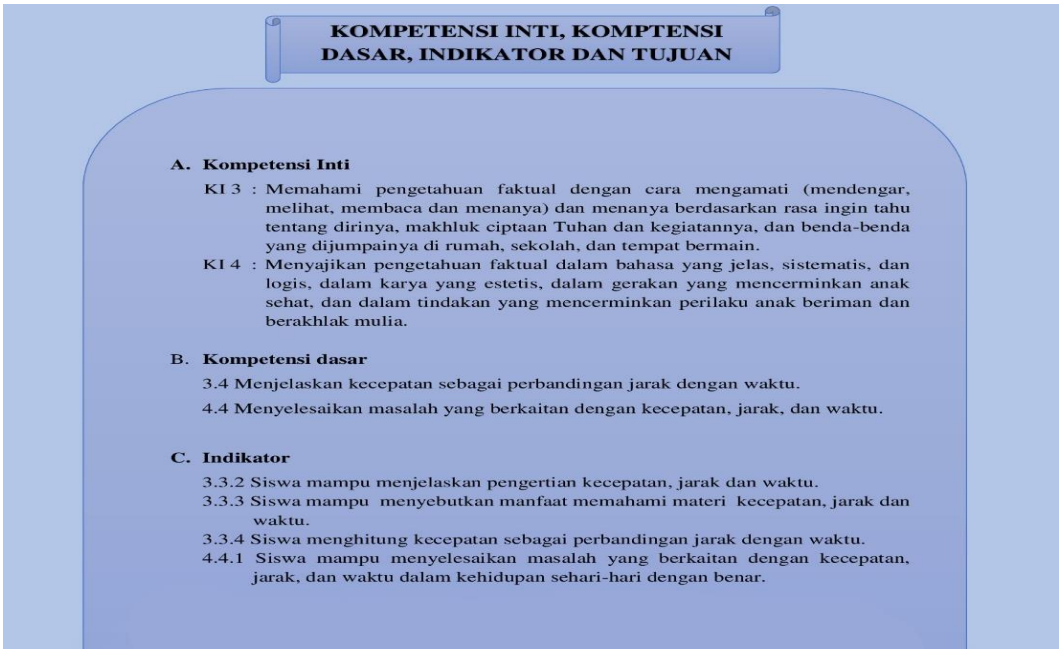



**Figure 3**: Before Being Revised In The Module Objective Section

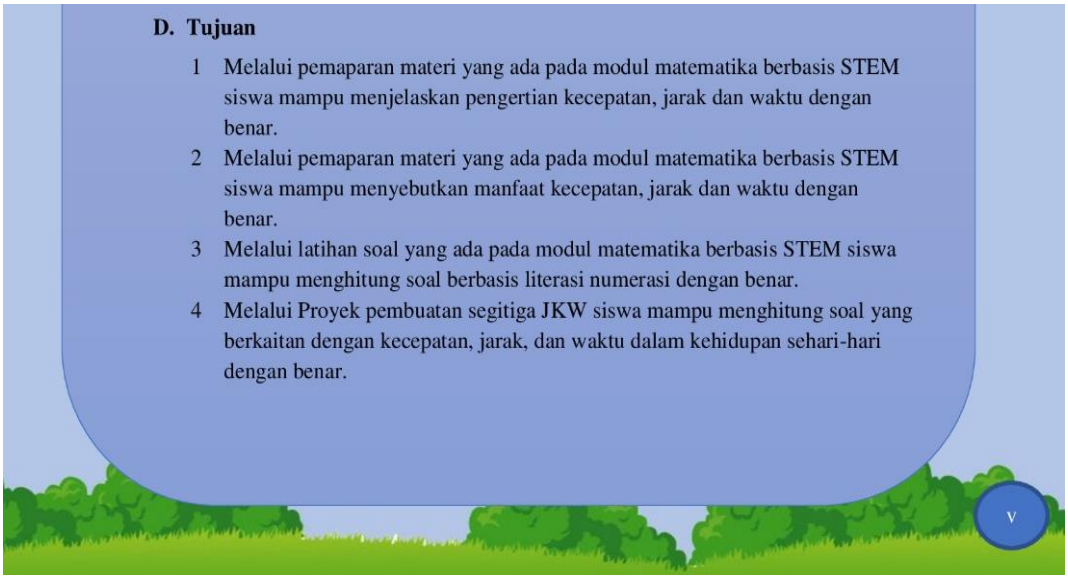
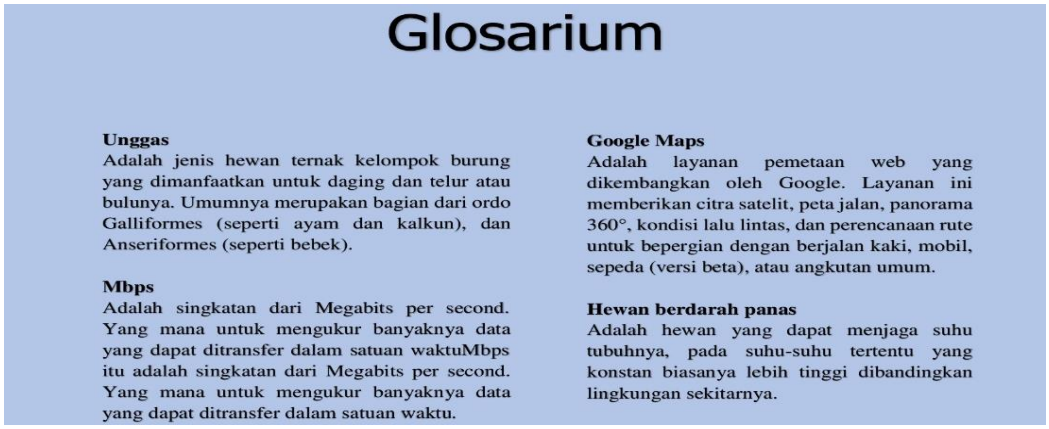



**Figure 4**. After Being Revised In The Module Objectives Section



Glosarium

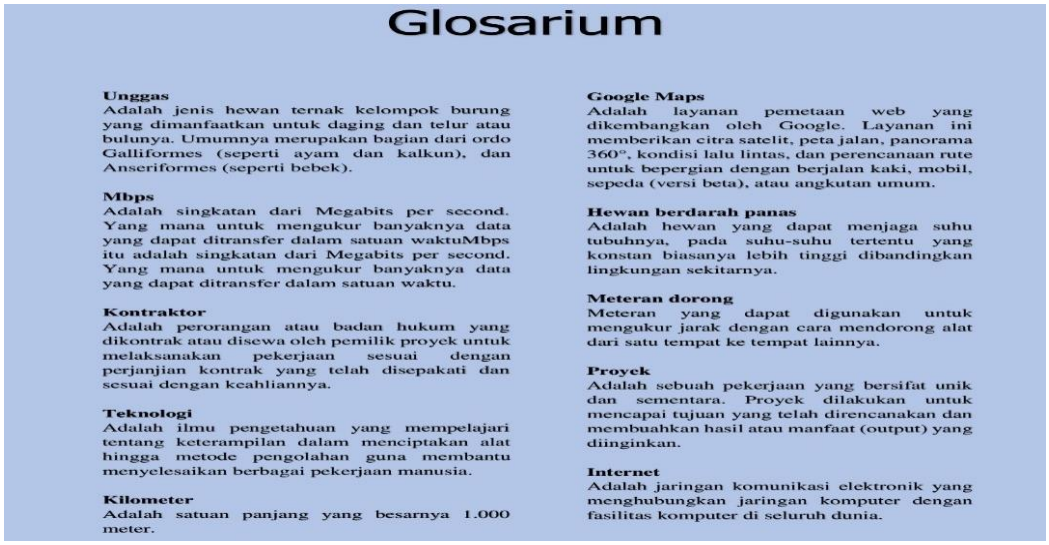
**Unggas**
Adalah jenis hewan ternak kelompok burung yang dimanfaatkan untuk daging dan telur atau bulunya. Umumnya merupakan bagian dari ordo Galliformes (seperti ayam dan kalkun), dan Anseriformes (seperti bebek).

**Mbps**
Adalah singkatan dari Megabits per second. Yang mana untuk mengukur banyaknya data yang dapat ditransfer dalam satuan waktuMbps itu adalah singkatan dari Megabits per second. Yang mana untuk mengukur banyaknya data yang dapat ditransfer dalam satuan waktu.

**Google Maps**
Adalah layanan pemetaan web yang dikembangkan oleh Google. Layanan ini memberikan citra satelit, peta jalan, panorama 360°, kondisi lalu lintas, dan perencanaan rute untuk bepergian dengan berjalan kaki, mobil, sepeda (versi beta), atau angkutan umum.

**Hewan berdarah panas**
Adalah hewan yang dapat menjaga suhu tubuhnya, pada suhu-suhu tertentu yang konstan biasanya lebih tinggi dibandingkan lingkungan sekitarnya.

**Figure 5**. Before Being Revised In The Glossary Section



Glosarium

**Unggas**
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**Kontraktor**
Adalah perorangan atau badan hukum yang dikontrak atau disewa oleh pemilik proyek untuk melaksanakan pekerjaan sesuai dengan perjanjian kontrak yang telah disepakati dan sesuai dengan keahliannya.

**Teknologi**
Adalah ilmu pengetahuan yang mempelajari tentang keterampilan dalam menciptakan alat hingga metode pengolahan guna membantu menyelesaikan berbagai pekerjaan manusia.

**Kilometer**
Adalah satuan panjang yang besarnya 1.000 meter.

**Google Maps**
Adalah layanan pemetaan web yang dikembangkan oleh Google. Layanan ini memberikan citra satelit, peta jalan, panorama 360°, kondisi lalu lintas, dan perencanaan rute untuk bepergian dengan berjalan kaki, mobil, sepeda (versi beta), atau angkutan umum.

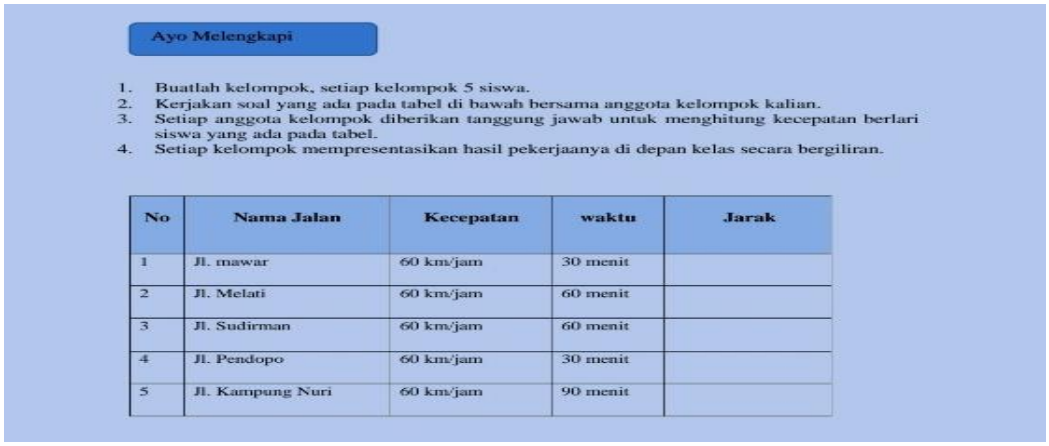
**Hewan berdarah panas**
Adalah hewan yang dapat menjaga suhu tubuhnya, pada suhu-suhu tertentu yang konstan biasanya lebih tinggi dibandingkan lingkungan sekitarnya.

**Meteran dorong**
Meteran yang dapat digunakan untuk mengukur jarak dengan cara mendorong alat dari satu tempat ke tempat lainnya.

**Proyek**
Adalah sebuah pekerjaan yang bersifat unik dan sementara. Proyek dilakukan untuk mencapai tujuan yang telah direncanakan dan membuahkan hasil atau manfaat (output) yang diinginkan.

**Internet**
Adalah jaringan komunikasi elektronik yang menghubungkan jaringan komputer dengan fasilitas komputer di seluruh dunia.

**Figure 6**. After being revised in the Glossary Section



Ayo Melengkapi

1. Buatlah kelompok, setiap kelompok 5 siswa.
2. Kerjakan soal yang ada pada tabel di bawah bersama anggota kelompok kalian.
3. Setiap anggota kelompok diberikan tanggung jawab untuk menghitung kecepatan berlari siswa yang ada pada tabel.
4. Setiap kelompok mempresentasikan hasil pekerjaanya di depan kelas secara bergiliran.

| No | Nama Jalan | Kecepatan | waktu | Jarak |
|---|---|---|---|---|
| 1 | Jl. mawar | 60 km/jam | 30 menit | |
| 2 | Jl. Melati | 60 km/jam | 60 menit | |
| 3 | Jl. Sudirman | 60 km/jam | 60 menit | |
| 4 | Jl. Pendopo | 60 km/jam | 30 menit | |
| 5 | Jl. Kampung Nuri | 60 km/jam | 90 menit | |

**Figure 7.** Before Being Revised In The Section On Improving Numeracy Literacy

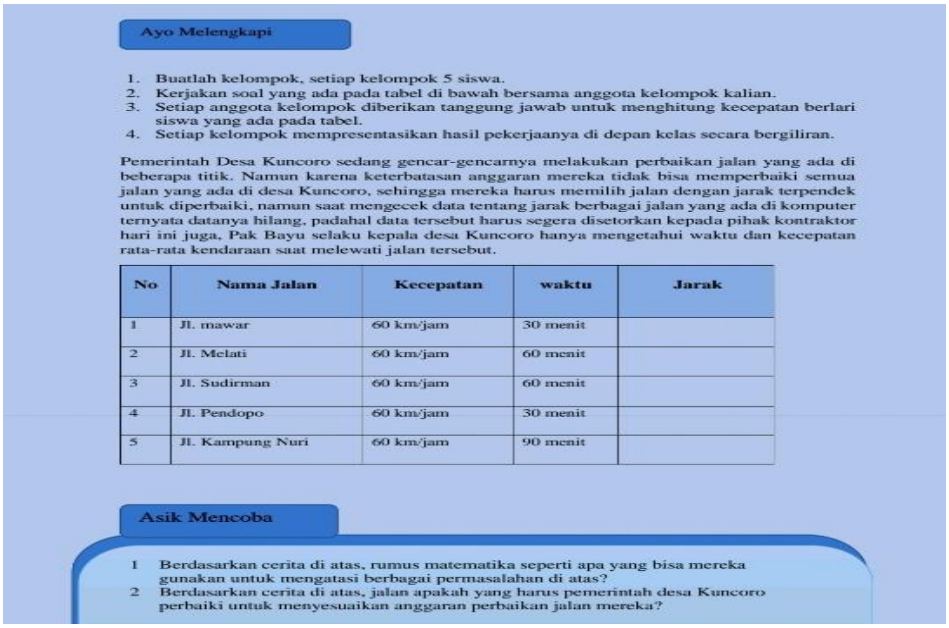



**Figure 8**. After Being Revised In The Section On Improving Numeracy Literacy.

After revising based on the suggestions, the researchers revised some other parts, such as the standardized spelling as suggested by the language expert. The researchers also revised the module flowchart based on the media expert's suggestion. The researchers revised the shortcomings based on the experts' suggestions. These revisions influenced the content and evaluation questions based on the numerical literacy indicators. The implication of these revisions was to improve the learners' numerical literacy skills. The revision to provide the module's objective would facilitate learners in determining the learning activity objectives. The revision of adding a glossary would facilitate learners in understanding new and non-familiar terms (Furqon, 2020). The addition of the bibliography list also broadened the insights of the learners. The addition of an integrated barcode with Google Forms on the developed module facilitated learners to submit the tasks. Thus, the learners could submit the tasks systematically and autonomously.

**The Characteristics of STEM-based Mathematics Module**

The STEM-based mathematics module development was based on the interview results of the teaching material needs. The developed materials in the module were velocity, distance,

and time. The researchers arranged the materials based on the module principle. The process of producing the module involved some supportive applications, such as MS Word 2019, Adobe Photoshop, Photoscap, and other applications. The applied font type was Times New Roman, with 12-20 font sizes. The researchers used this font type and font size to make the module readable and clear. Nurhadryani (2013) also showings that Times New Roman with 12-20 font sizes could facilitate learners reading.

The characteristics of the STEM-based mathematics module included three main parts: the front part, the content, and the rear part. The front part consisted of a cover, preface, table of content, module instruction for teacher and learner, core competence, basic competence, indicator, objective, material conceptual map, and STEM-conceptual map. Ridwan (2021) showings that the front part of a module should contain cover, title, education level, page cover of STEM-based mathematics module, and figures related to speed, distance, and time; STEM-approach, composer, curriculum, and institution. The novelty of this STEM-based mathematics development was observable on the cover part. In the previous research, the researchers did not add figures about the materials – speed, distance, and time; or the figures about STEM and various figures about numerical literacy and self-directedness.

The preface, table, of content, module instruction, core competence, basic ompetence, indicator, and learning objective in this module were not different from the previous research, for example by Zulfikar (2019). The researcher showings that front part of a teaching material should contain preface, table of content, module instruction, core competence, basic competence, indicator, and learning objective. However, in this STEM-based mathematics development, the researchers put colorful preface, table of content, module instruction, core competence, basic competence, indicator, and learning objective. The researchers also put some animation so that learners were interested. Indriani (2022) showings that teaching materials should contain attractive figures for the learners.

The conceptual map of the STEM-based mathematics module consisted of two parts: the material conceptual map and the STEM conceptual map. The material conceptual map consisted of some materials about diagrams of speed, distance, and time. Widya (2018) also found that diagrams could facilitate learners' material understanding and construct various intercorrelated notions.

In this research, the researchers also provided various interesting figures based on the developed materials. Yuswati (2019) found that figures could attract learners to study. The difference between the module's conceptual map and the previous study was the added STEM conceptual map with some supporting figures. A previous study, for example by Annisa (2020), did not provide a STEM conceptual map and any supporting figures.

In this research, the content part of the developed module consisted of speed, distance, and time with various supporting animated figures to facilitate learners' understanding. Fauzi (2017) also showings that teaching material must attract learners' attentions. The STEM approach in this module facilitated the learners in studying mathematics. Niam (2021) and Oktavia (2020) showings that STEM could facilitate learners' mathematics understanding. The differences between the current developed module and the previous module were the improvements in numerical literacy and self-directedness with the implementation of real-life problem provision. This action trained the learners to use various numbers, symbols, and related fomulas to solve daily life problems and analyze the information, such as graphics, tables, charts, and diagrams. The applied technology, in this research, was installed and implemented to facilitate the mathematics learning.

The researchers expected the STEM approach could make mathematics learning to integrate all elements in the real world instead of focusing on numbers, symbols, and data. Susanti (2020) also found that the STEM approach could facilitate learners' mathematics material understanding. The current developed module had various adjusted activities based on the

indicators of learners' self-directedness. The developed module also had additional features, such as literacy, environmental-adjusted material based on the learners' conditions, questions with figures, question-answer, etc.

The last part of the module consisted of summary, evaluation, keyword, glossary, and bibliography. The summary consisted of the summarized materials about speed, distance, and time to facilitate the learners in reviewing the materials. The glossary was similar with personal dictionary with many new terms arranged alphabetically. The evaluation questions of the module had the integrated barcodes with Google Forms, consisting of numerical literacy-based questions to evaluate learners' understanding and numerical literacy skills. They key answers consisted of evaluation answers so that learners could correct their works. The bibliography consisted of the reference. Kristia et al., (2016) found that final part of a teaching material should contain summary, evaluation, key answer, glossary, and bibliography. In this research, the researchers' developed module was different from Annisa (2020) who focused on numerical literacy-based evaluation questions.

**The Readability of the STEM-based Mathematics Module**

The readability analysis of the STEM-based mathematics module applied a cloze-test. Rinaldi (2022) showings that a cloze test is a successful testing technique to examine readability levels. Sabarua (2020) also showings that a cloze test is excellent to examine readability by making some parts of a sentence blank in the module. Then, the learners must fill in the blanks in the sentences. In this test, the researchers omitted 10 words in sentences. Then, the researchers asked the learners to fill in the blanks of incomplete sentences.

The developed module obtained a percentage of 88%. The result met the requirement to make the readability decision. Miliah (2012) showings that the readability percentage of teaching material must be higher than 60%. This standard indicates the independent category and the excellent readability of teaching material. Niam et al., (2020) Also found that the developed STEM-based mathematics module had excellent readability, proven with a percentage of 87%. This result was categorized as independent or readable.

**The Practicability of STEM-based Mathematics Module**

The analysis results of the practicability were useful to determine the learners' and teachers' attractiveness to the developed module. The researchers distributed the questionnaire to both teachers and learners. Hufri et al., (2019) also distributed a questionnaire about practicability for the teachers and learners to determine their product practicability.

Based on the response calculation of the questionnaire from the fifth-grade teachers with Likert-scale measurement, the researchers found that the teachers were interested. The obtained questionnaire scores were 92 and 87, categorized as very interesting. From the results, the developed module was reliable for textbook and additional reference to support the learning process. Hasanah et al., (2020) also found that STEM-based mathematics modules had excellent practicability. The result indicated that the teachers and learners had excellent responses toward the developed module for further implementation. The developed module implementation also made the class interesting because the module was colorful. Carolina., (2019) also found that teaching materials should have put interesting figures. The teachers also stated that the developed module provided a new experience for learners to solve behavioral problems they encountered by implementing mathematics formulas. Besides that, the fifth-grade teachers also thought that the developed module facilitated concrete learning so that the learning did not only focus on numbers, formulas, and symbols. The learning became interesting because the learning connected mathematics and the environment. The learners also thought they wanted to solve the problems with mathematics. Megawati (2021) also found that an excellent learning approach could

improve the numerical literacy skill of learners. The activities in the developed module could improve the numerical literacy and the self-directedness of the learners.

After promoting the practicability test, by distributing the response questionnaire to the fifth-grade teachers, the researchers examined the practicability by distributing the questionnaire to the learners at the schools. The results showed that the learners were interested in the developed module. The obtained mean score was 54.5. The analysis of the Likert scale obtained a maximum score of 60. Thus, the result of the percentage was 90%, categorized as very interested. Utami (2018) also found that STEM-based mathematics modules received excellent responses from the attracted learners. The learners thought the STEM-based mathematics module was interesting. They argued that the applied language was understandable to showings the material of speed, distance, and time. Based on the practicability questionnaire responses from the teachers and learners, the researchers concluded that the developed STEM-based mathematics module was very interesting with a percentage of 89%. Thus, the developed module had excellent practicability levels and was interesting for the learners and the teachers.

**The Effectiveness of the STEM-based Mathematics Module toward the Numerical Literacy and Self-Directedness of the Learners**

After applying the cloze test, the next phase was promoting a product trial run to determine the effectiveness of the developed product in improving the numerical literacy and self-directedness of the learners. The researchers tested the module at five primary schools in Munjungan district, Trenggalek regency. The researchers examined the effectiveness of the developed module with the learners' learning outcome completion based on the pretest and posttest results. The following is an example of a sample of pretest and posttest results.

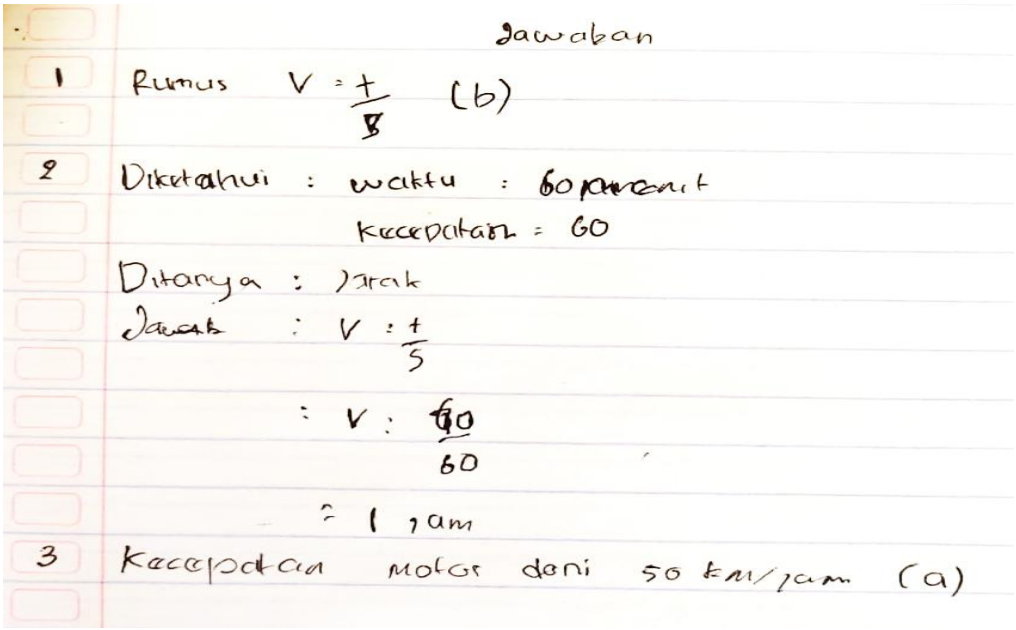



**Figure 9**. Sample Pretest Results Before Students Use the Module.

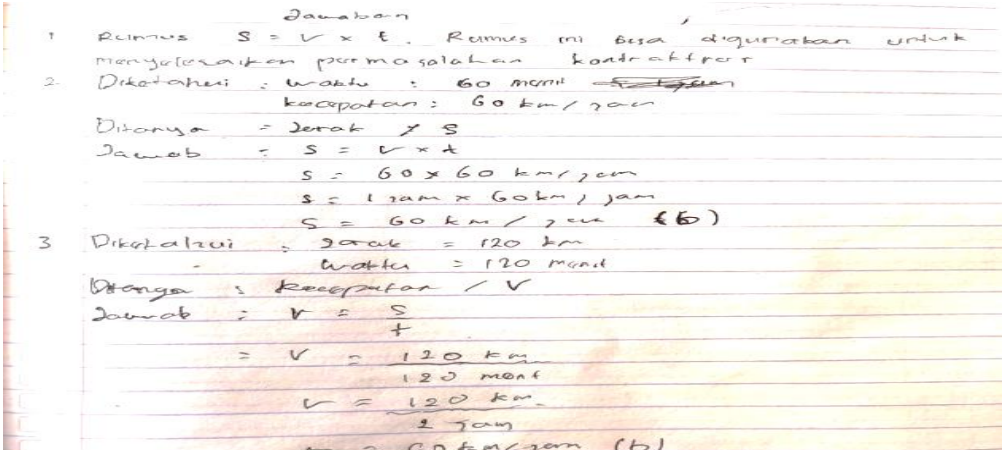


**Figure 10**. Sample Posttest Results After Students Use the Module.

Based on the picture, 10 students were able to correctly answer all numeracy literacy-based posttest questions on the subject of distance, time and speed. The posttest results showed 32 learners out of 37 learners reached the minimum learning completion with the learner classical completion of 90%. On the other hand, the minimum standard mastery score was 75. The result indicated that the classical completion was more than 85% of learners. Most learners surpassed the minimum standard mastery. Hutam (2019) found that a class with classical completion had to meet a criterion - more than 85% of learners had to surpass the minimum standard mastery. The highest learning outcome, with the implementation of a STEM-based mathematics module, was 95 while the lowest one was 70. The mean score of the learners was 87. These results indicated that the STEM-based mathematics module implementation was effective to improve the numerical literacy of the learners. Sari et al., (2021) also found that STEM-based mathematics module was effective to improve the numerical literacy of learners. The following is a numeracy literacy achievement figure for each indicator as follows:

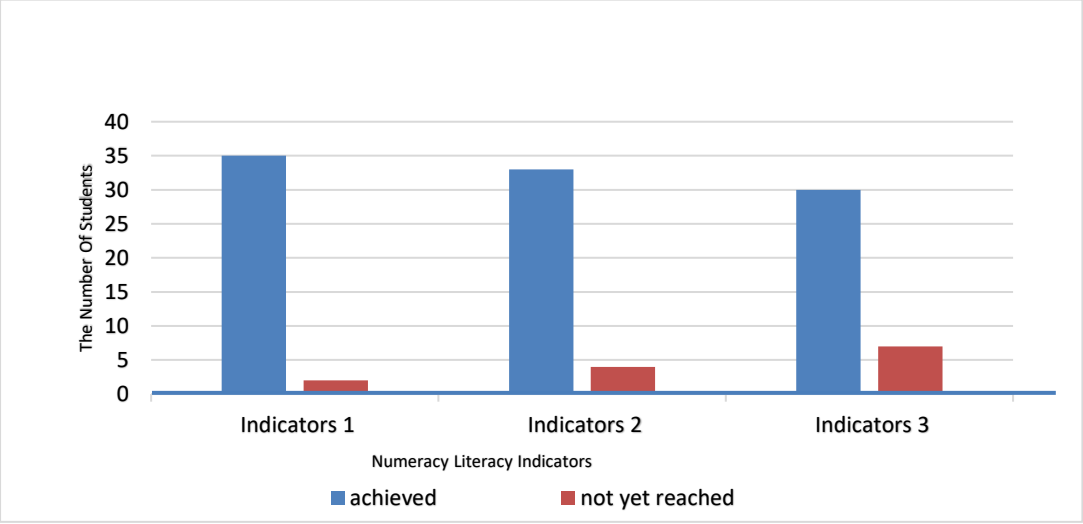



**Figure 11**. Achievement Of Numeracy Literacy Indicators

Based on the figure chart above, it can be drawn that the students' numeracy literacy skills have been achieved in all indicators. The N-gain value also showed that the numerical literacy skill score was 0.6. The results indicated an improvement from the pretest to the posttest. The results were different between the pretest and the posttest, before and after the implementation of the STEM-based mathematics module. The pretest results of the learners obtained a mean of 63. The post-test result of the learners obtained a mean of 85. Besides the capability to improve

numerical literacy skill, the developed module was effective to improve the learners' self-directedness. The evidence was observable in the questionnaire on learners' self-directedness. Based on the questionnaire, the researchers found the mean percentage score of self-directedness was 70%, categorized as adequately excellent. The result indicated that the self-directedness of the learners after applying the developed module improved. Suryani et al. (2020) also found that the STEM-based mathematics module excellently influenced the improvement of learners' self-directedness.

The novelty of this research was observable in the learners' skills in using mathematics symbols and numbers; and in the information analyses, starting from graphics, tables, and charts to solve various real-world problems. Besides that, the module had integrated barcodes with Google Forms to facilitate the learners submitting their tasks autonomously and to support online learning. The previous studies did not focus on improving the learners' skills in using mathematics symbols and numbers; and in the information analyses, starting from graphics, tables, and charts to solve various real-world problems. The previous studies also did not integrate the teaching material and the evaluation questions with Google Form to assist online learning and task submissions, for example, the study by Lidyawati (2022).

## CONCLUSION

The characteristics of the STEM-based mathematics module, in the printed version, had the focus to improve the numerical literacy skills and self-directedness of the learners. This STEM-based mathematics module with the materials of speed and time was valid and applicable for learning. The evidence was the validation results of the three experts. The STEM-based module had excellent readability, proven by the cloze test. The result indicated that the readers of the STEM-based mathematics module were categorized as an independent. The practicability test also showed that the developed module was very practical. The developed module also had excellent reliability, readability, practicability, and effectiveness to improve the numerical literacy skills and self-directedness of the learners. The evidence was observable in the classical completion and N-gain test and the questionnaire results. The STEM-based mathematics module could improve the numerical literacy skills and self-directedness of the learners.

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