

Development of statistics teaching materials with a STEM approach to improve mathematical communication skills in online learning

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Abstract: This study aims to develop STEM-based Teaching Materials with a STEM approach to Online learning. Post-COVID-19 pandemic, online learning is a familiar form of activity, so post-pandemic learning and learning design must be developed, especially to measure students' mathematical Communication skills. This study used the study and Development study methodology with the ADDIE Model. The sample in this study was 80 students. This study showed a significant difference of 0.44, which stated that using STEM teaching materials was better than regular learning in mathematical Communication skills. Two factors, namely ease of access to teaching materials and ease of repeating teaching materials, affect students' Communication skills.

Keywords: Development of Teaching Materials; Mathematical Communication; STEM Approach

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Introduction

COVID-19 has an impact on the learning process. One of them is the learning process that must be carried out fully online. Several obstacles certainly occur, especially in mathematics learning. One of them is the process of delivering material, which is usually easy to do directly, which becomes difficult because you can't freely write on the board (Sofwan, 2020). The material in mathematics learning also needs to be explained because it is new material, and students are not familiar with it at all (Hadi, 2020). Especially teaching materials in Statistics courses that require explanations. This certainly requires creativity from mathematics teachers so that the explanation of the material can be understood by students. So, it is necessary to develop teaching materials and teaching styles that adapt to online-based learning in order to prevent the spread of COVID-19.

In March 2020, learning in Indonesia was carried out online based on a circular from the Minister of Education and Culture of the Republic of Indonesia (Surat Edaran Nomor 4 Tahun 2020 tentang Pelaksanaan Kebijakan Pendidikan dalam Masa Darurat Penyebaran Corona Virus Disease (Covid- 19), 2020). Online-based learning is implemented at various levels of education, including the tertiary level. In mathematics lectures, many obstacles are faced, one of which is that the explanation given is not easy to understand due to network factors, and the mathematics teaching materials provided by the teacher cannot be understood by students (Kusumaningrum & Wijayanto, 2020). According to Utami (Putri Utami & Alan Dheri Cahyono, 2020), 75% of students' learning difficulties are experienced due to the difficulty of interaction during mathematics learning. Interaction during online learning depends on the teaching materials prepared by the teacher during online learning. The teaching materials prepared should consider the Learning Management System (LMS) so that learning objectives can be achieved (Sudianto dkk., 2019).

LMS is used as a full online learning media. Some use Moodle, e-learning, Google Classroom (GC), Edmodo, and so on. According to Najila (Nurani dkk., 2020), Google Classroom is one of the LMSs that can facilitate teacher and student learning activities, although its use needs to be supported by several appropriate teaching materials. The use of Google Classroom also needs to consider variations in learning strategies and the use of ICT media so that learning can be easily adapted by students (Firman Annur, 2020). Therefore, variations in methods need to use learning approaches that are in accordance with variations in teaching materials so that online learning is not monotonous and easy for students to understand, especially for mathematics learning. This study will examine the development of teaching materials that consider aspects of students' digital needs.

STEM (Science, Technology, Engineering, and Mathematics) is one approach that provides variation in learning (Jauhariyyah, 2017). STEM is an approach that combines concepts and logical thinking, so development using this approach will be more varied. STEM uses a project-based approach so that students explore. The development of learning modules using the STEM approach also makes the module more interesting for students (Utami dkk., 2018). Teaching materials developed with the STEM approach can offer a variety of interesting teaching materials. This is so that learning objectives can be achieved. Based on the description above, this study is an effort for mathematics teachers to innovate by developing teaching materials. In developing these teaching materials, it is necessary to consider the suitability and feasibility of the current conditions. This study aims to develop online learning using the STEM approach to improve students' mathematical Communication skills.

Method

The type of study used by researchers is study and development. According to Creswell, study with study and development techniques is study by designing a particular product, which is then tested for effectiveness and validity to determine the readiness of the product to be used by the wider community (Creswell & Poth, 2016). The development Model chosen in this type of study is the ADDIE Model, which has five stages of development, including analysis, design, development, implementation, and evaluation. This method can be used in developing various things to support the learning process, including models, methods, media, and teaching materials. The subjects in this study and development were students at the Ponorogo State," Islamic Institute located at Jalan Pramuka No. 156, Ponorogo Regency, East Java 63473. This study uses purposive sampling. Purposive sampling is a sampling technique that determines sampling based on study objectives (Robinson, 2023). The study was conducted in the 2021/2022 academic year with subject specifications for prospective educators totaling 80 students consisting of 4 classes. Development study using the ADDIE Model has five stages that must be passed, including analysis, design, development, implementation, and evaluation. This study's evaluation used a test to measure students' mathematical Communication skills. The evaluation was done by comparing the experimental class that used development with those that did not use the development Model. Development study using the ADDIE Model has the following development design phases.

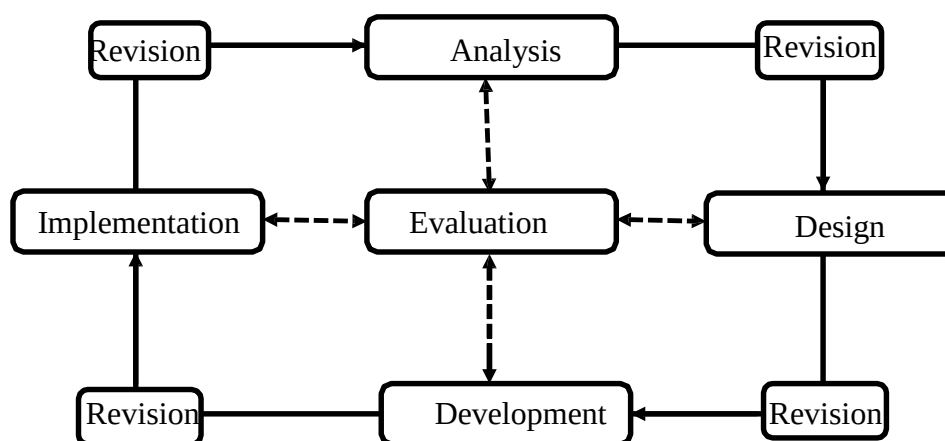


Figure 1. ADDIE Scheme.

Results and Discussion

In this study, the development process with the ADDIE approach involves the stages of Analysis, Design, Development, Implementation, and Evaluation. The development procedure will be explained below.

Needs Analysis

A needs analysis was conducted to determine the need for basic statistics learning at IAIN Ponorogo and to determine the learning conditions after the pandemic. This is to design online learning that suits the needs. At this stage, needs analysis was conducted by interviewing colleagues and four students taking Basic Statistics courses. This interview activity aims to determine the design of online learning with a STEM approach that suits the needs of the lecture. Based on the results of interviews conducted with colleagues, Mrs. Ulum Fatmahanik (Fatmahanik 2022). Learning was carried out offline in 2022 at IAIN Ponorogo. According to Mrs. Ulum, even though learning was offline, students were accustomed to online learning because it had been implemented for more than 1 year. So that online learning currently needs to be designed online so that students can easily access teaching materials and submit assignments. In fact, according to him, submitting assignments online makes corrections and grading more straightforward and more efficient. Moreover, students are also used to submitting assignments entirely online.

Based on interviews with students, post-pandemic students are more interested in digitally documented teaching materials. Moreover, almost most students have devices that can be used to access teaching materials online, either mobile phones or laptops. So that currently, fully online learning is also less efficient, according to students. Learning that is packaged digitally makes it easier for students to access material that has been delivered by lecturers and can also replay it if there is a video that they may not have understood in class. However, offline learning is also essential for students because they need direct interaction and teacher Communication.

Student analysis is used to see student character so that it is by the function of developing STEM-based Statistics teaching materials. The characteristics of students who take Basic Statistics courses are those who are familiar with IT. This is because students have experienced full online lectures for 1 year. Students are very enthusiastic about using gadgets, especially those related to mobile phones. So everything, including teaching materials, really wants to be digital-based. Digital-based teaching materials that students want are, of course, practical and can be accessed directly. This is because the mobile phones owned by students are also not high-spec. So, the teaching materials used are highly desired in the form of a network without installation.

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Design

After analyzing the development of teaching materials, several schemes were drawn up for making teaching materials. STEM-based Statistics teaching materials are made through a network (website). Website design uses website design created by Google (Google site). Google Site was chosen because it is integrated with familiar Google applications, such as Google Form, Google Drive, Google Docs, and YouTube. Google Sites also offers convenience in website design because it does not use complicated coding. In addition, IAIN Ponorogo collaborates with Google on the Google Education platform, which allows users to have more storage capacity and be more efficient in online storage rental.

Google Sites has several features that can be used to create learning website designs. There are page menus, themes, and inserts that are enough to create a website appearance. The Google site provides the website theme with easily read and visible colors. The page presents a composition that we can set. Insertion contains content from the website that we can easily drop into the website. Simple website display settings make it easier for researchers to create digital teaching materials. The website design features needed in creating teaching materials are the placement of PDF, PPT, and image files to upload the main material. Students can access the material and can be downloaded if needed. In addition, online teaching materials also present video content in the form of YouTube and Google Form-based assignment collections. Google site also has a domain facility that can be customized so that students do not have too much difficulty accessing the website.

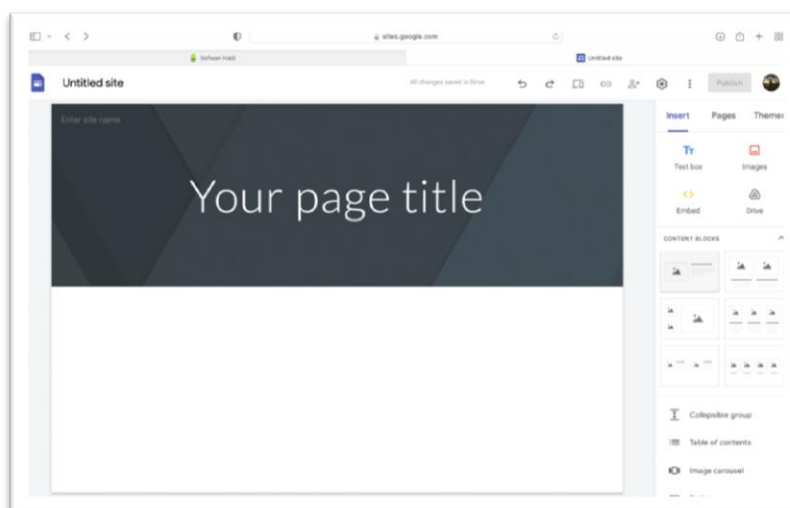


Figure 2. Google Site View is used to develop teaching materials

Development

The development of Statistics teaching materials takes into account the STEM Approach. In the development of online teaching material products, it is arranged in the following scenarios:

Science

Product development science is arranged to link the material to everyday life. In introductory statistics teaching materials, the mean material of everyday life is shown in printed teaching materials such as handouts and teaching materials in the form of videos. In printed teaching materials, students are invited to pay attention to student grades and height data. In the video, everyday life is told orally by the speaker. This is for the material to determine the Mean value to be understood by students in tangible form.

Technology

Technology is the skill of using electronic devices. When using teaching materials, students access them using mobile phones or laptops. In addition, when working on the material, students are also required to be skilled in using calculating tools, be it calculators or laptops, especially when determining the amount of data or adding up columns to determine the mean value (average).

Engineering

Engineering is a skill according to procedures. In the material on determining the Mean value for both single and group data, students must follow the applicable guidelines. Of course, the method ensures that the student's work results are accurate and not wrong. Technical skills are included in teaching materials. Teaching materials are arranged so that assignments can be done according to the procedures on YouTube and in PPT/PDF materials.

Math

Mathematics is a skill in making logic. In the material on determining the mean value, logic is needed to obtain the answers on the student's worksheet. In the teaching materials, the ability to reason is conveyed by providing examples in the material on the video and teaching materials. In addition, the ability to reason is also emphasized in student work. The scenario for developing teaching materials is based on the design of the STEM elements made in Figure 3. Teaching materials contain everyday life and the logical process of obtaining mean value results. In the video, everyday life values, calculation procedures, and logical reasoning will also be explained verbally.

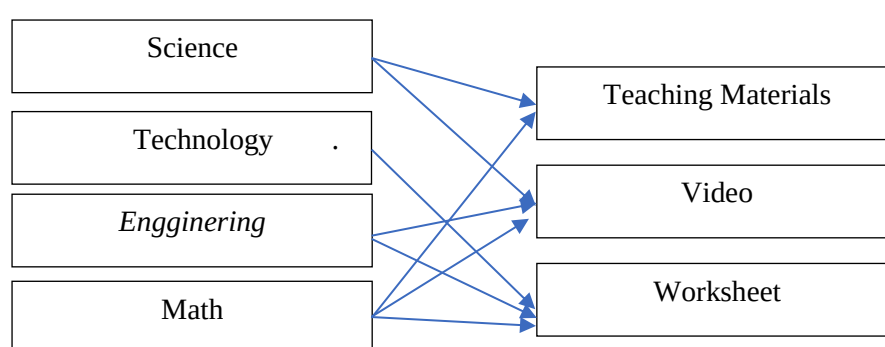


Figure 3. STEM Scenario

Implementation

Implementation of the Validity of Teaching Materials by expert validators aims to determine the feasibility of the development that has been prepared. The validation tests include Materials, Learning Techniques, Language Use, and Use of Learning Technology. The results of Expert Validation produce the following teaching material display:

Developer Identity Page

This page contains the developer's profile and contact person. This page is created so that users (students) can easily interact directly. On this page, a profile photo of the developer is prepared, and the user can use several contact numbers to contact them. The contacts provided are in the form of a mobile phone number and email. In addition, this section also provides a social media address in the form of Instagram. Instagram as a social media was chosen because students who take the course are very active in using this social media. Other social media are deliberately not listed to break the user's concentration. In addition, the Developer Identity page also lists the developer's work location, namely at the IAIN Ponorogo campus, so that users other than students can easily find the developer's location if they want to discuss or ask about material that is not clear.

Presence Page

The presence page generally consists of 2 components: a table of contents for attendance to make it easier to search for attendance and attendance according to the meeting. Attendance is created using Google Forms. This attendance functions to control user participation (students) during online learning. Attendance is created with a time limit to check whether the user (student) opens the Online Teaching Material during the specified period.

Teaching Material Page

The general teaching material attendance page consists of two components: a table of contents and material content. The content of the teaching material is adjusted to the needs. Generally, it will be given in PPT, PDF, EXCEL, and Video. Video is used as a substitute for delivering material in Online Statistics learning. PPT contains material presented during learning through Video. Video is presented on the material page in the form of YouTube uploads. This is to reduce website storage and make it easier for users to access. A direct face-to-face video is designed as a video reaction showing the speaker's face and body. The face and body are demonstrated deliberately so that users know the emphasis of the speech when the material is explained. As a substitute for the whiteboard in Direct Learning, MS Word and PowerPoint are prepared to explain the delivery details. In the Video, STEM elements are included, including examples of data in everyday life (Science), the use of calculators and Excel (Technology), the sequence in finding the Mean value for single and group data (Technology), and rechecking the accuracy of the calculations (Mathematics). This results in the Video having a long duration. In addition to the Video, the teaching material is equipped with documents in the form of PPT, PDF, and Excel. These accompanying documents are used to help explain the teaching material. The PPT document only contains content related to the introduction of everyday life (Science) and the procedure for finding the Mean value (Technology). In the Excel file, applications help with calculations (Technology). The PDF that provides direct calculation notes contains the procedure for finding the Mean value (Technology) and drawing conclusions from calculations (Mathematics). The availability of supporting documents is essential in developing STEM-based online teaching materials. Because STEM values are included in it

Assignment Page

The assignment page consists of a Google form and assignment instructions. The assignment instructions are in the form of a PDF file. PDF files have advantages in readability when accessed compared to images such as JPG and PNG. In addition, PDF file security is also the most appropriate because users cannot access and change the contents of a document, unlike document types (doc), in the assignment use Google Forms. Google Forms was chosen because it has a document upload facility. This assignment uses a STEM approach by providing examples of exercises in the form of everyday problems (Science)

Evaluation

Before data calculation is carried out, the study hypothesis needs to be determined. This is done so that the results of the t-test calculation can be concluded. The following are the hypotheses prepared in this study.

$H_0: \mu_2 = \mu_1$ (There is no difference in the Communication skills of students in classes that use STEM-Based Statistics Teaching Materials and those that do not use STEM-Based Statistics Teaching Materials)

$H_1: \mu_2 \neq \mu_1$ (There is a difference in the Communication skills of students in classes that use STEM-Based Statistics Teaching Materials and those that do not use STEM-Based Statistics Teaching Materials)

Furthermore, from the determination of the hypothesis that has been prepared, it will be seen whether there is a difference in Communication between students who use and do not use STEM-Based Statistics Teaching Materials. After the hypothesis has been prepared, the Parametric t-test calculation is carried out to see if there is a difference between classes that use STEM-Based Statistics Teaching Materials. The following are the results of the t-test calculation from the data obtained.

Table 1. t Test Communication Values

Communication Values	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.073	47	.044	3.51003	1.69306
Equal variances not assumed	2.067	45.6	.044	3.51003	1.69825

From Table 1, the Significance value of the t-test is less than 0.05, which means that H_0 is rejected. This means that there is a difference in the Communication skills of students in classes that use STEM-Based Statistics Teaching Materials and those that do not use STEM-Based Statistics Teaching Materials. From Table 21, a t-value of 2.073 is also obtained, which is positive, indicating that the Communication Skills of students who use STEM-Based Statistics Teaching Materials are better than those who do not use STEM-Based Statistics Teaching Materials. Based on the conclusion that STEM-Based Statistics Teaching Materials have been proven to improve students' Communication skills. In this discussion, there are several supporting aspects as follows:

Ease of access

Website-based learning allows for easy learning from anywhere. Comfortable places and conditions enable learning to be well received. This aligns with Dian's opinion that understanding digital literacy is influenced by mood (Pratiwi & Pritanova, 2017). Website-based learning makes it easy for students to determine their mood and comfort during learning. With a comfortable mood, students find it easier to write down the results of their work in the form of written answers.

Ease of Repeating Material

STEM-Based Statistics Teaching Materials have facilities in the form of videos and materials. According to Irfan, students taking Statistics courses and videos have the advantage that when they do not understand the lecturer's explanation, they can stop the duration (Hadi, 2022). In addition, the calculation documents written in the video make it easier for students to understand the material when the explanation is unclear. This is supported by Fakhriyana's opinion that interactive videos can improve students' understanding compared to those who do not use interactive videos (Fakhriyana & Riayah, 2021) Good experience is certainly related to Communication skills. Especially when students provide symbols from calculations from the formulas given

Conclusion

Based on the study results presented previously, it can be concluded that the development of Statistics Teaching Materials with the STEM approach is suitable for online learning. This can be seen from several Expert Validation tests that obtained more than 85% from material, learning design, language, and learning technology. The STEM-Based Statistics Teaching Materials development Model in this study was developed with the Google site program, which has three views for Computer/PC, Tablet, and Mobile Phone devices. STEM-Based Statistics Teaching Materials that use website media allow students to access materials from anywhere. Based on the trial results, the t-test significance value was obtained at less than 0.05, which means H_0 was rejected. This means there is a difference in the Communication skills of class students who use STEM-Based Statistics Teaching Materials carried out online and those who do not use STEM-Based Statistics Teaching Materials carried out offline. In addition, it also indicates that the Communication Skills of students who use STEM-Based Statistics Teaching Materials are better than those who do not use STEM-Based Statistics Teaching Materials. Using Statistics Teaching Materials with the STEM Approach can improve students' Communication skills because of the material's ease of access and repetition. Of course, this is all due to the selection of the website as the development Model.

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