



Implementation of multimedia interactive learning through a STEM approach based on computational thinking to improve student learning outcomes

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ABSTRACT

This research was conducted to measure student learning outcomes using interactive multimedia with a STEM approach based on computational thinking in the informatics subject on binary numbers in class VII SMPN 1 Batujajar. The type of research used is quasi-experimental. The sample used was class VII D with a total of 32 students. The data used in this research used a pretest and posttest by giving 20 questions. Test testing is carried out by testing validity, reliability, difficulty index, and distinguishing power of questions. Data analysis uses score gain. The average pretest score before being given treatment using interactive multimedia was 50.5 and the average posttest score after being given treatment using interactive multimedia with a problem based learning model was 84.2. Thus, a gain value of 0.6814 is obtained in the medium category. It can be concluded that interactive multimedia with a STEM approach based on computational thinking can improve the learning outcomes of class VII D students at SMPN 1 Batujajar in the informatics subject on binary numbers.

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INTRODUCTION

Entering the 21st century, science and technology are developing very rapidly, this is because there are no boundaries between countries in communication and cooperation. The main principles in 21st century learning include student-centered learning, learning must be linked to everyday life and schools are able to facilitate students to be involved in their social environment (Syahputra, 2018). This principle can be the basis for a teacher in determining a method or approach that will be used when teaching, one of which is STEM. STEM is able to create a cohesive learning system and active learning, because the four aspects, namely Science, Technology, Engineering, and Mathematics are needed simultaneously to solve problems (Agnezi et al., 2019). Learning using a STEM approach can provide students with opportunities for scientific inquiry, technological literacy, mathematical skills, and design techniques (Kelley & Knowles, 2016). The STEM approach also has positive implications for the creativity and abilities generated by students in solving

problems given in learning (Syarah et al., 2021). This shows that the implementation of the STEM approach in the learning process not only makes students gain knowledge and skills, but also students discover the process of how to maximize the knowledge and skills they have for learning.

Through Minister of Education and Culture Decree No. 262/M/2022 in its changes to the independent curriculum reintroduces computers as a subject in schools called informatics subjects. This subject is one of the mandatory subjects implemented in the independent curriculum to support students in managing technology. With the addition of Informatics subjects to the independent curriculum, it is hoped that it can help students in solving problems, thinking critically, innovating, and building a spirit of collaboration through the use of technology. The basic competencies raised in informatics are quite challenging in training students' critical thinking. Students not only know and operate office applications, but the informatics material discusses computer hardware, operating systems and various software, processing data, getting to know and using visual programming, collaboration in a digital society and getting to know and apply the concept of computational thinking. computing).

Computational thinking was first introduced by Seymour Papert in 1980 and 1996. Initially, the definition of Computational Thinking was a way of thinking used by computer scientists to solve a problem. (Wing 2006, n.d.) revealed that Computational Thinking is a basic skill for everyone, not only for computer scientists. Learning using computational thinking skills is a basic skill in the entire school curriculum, which allows students to learn to think in solving problems in a gradual, abstract, algorithmic and logical manner, and be ready to solve complex and open problems (Yasin 2020, n.d.). (Novianti & Dewi, 2023) said that the characteristic aspects of computational thinking include decomposition (decomposing a problem into sub-problems), pattern recognition (identifying similarities, regularity of data), abstraction (formulating principles-general principles that produce recognized patterns), and algorithms (developing appropriate steps/instructions to solve a problem or then other similar problems).

The use of learning media is an inseparable part and has become an integral part of the learning methods used (Sulistiani et al., 2020). (Hasanah, n.d.) states that learning media is generally defined as tools, methods and techniques used to facilitate communication and interaction between teachers and students in a more effective education and teaching process. Teaching materials are a source of knowledge for students at school which really supports the process of teaching and learning activities. By integrating teaching materials on technology, information and communication (ICT), students' learning motivation is expected to increase (Pricilia et al., 2020).

Interactive multimedia-based teaching materials can replace teachers in the classroom, allowing students to understand the material and ask questions that train computational thinking. Interactive multimedia displays a combination of text, images, animation, sound and video that engages many of the senses in learning. This approach can make it easier for students to understand the material because the more senses are involved in the learning process, the more effective learning will be (Marina Angraini, 2022a). and algorithms (developing appropriate steps/instructions to solve a problem or then another similar problem). The use of learning media is an inseparable part and has become an integral part of the learning methods used (Sulistiani et al., 2020). (Hasanah, n.d.) states that learning media is generally defined as tools, methods and techniques used to facilitate communication and interaction between teachers and students in a more effective education and teaching process. Teaching materials are a source of knowledge for students at school which really supports the process of teaching and learning activities. By integrating teaching materials on technology, information and communication (ICT), students' learning motivation is expected to increase (Pricilia et al., 2020).

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Learning is one of human nature in living life. Every human being has an instinct within him that always upgrades himself through learning. Daily activities can be said to be learning, both at home and at school. Through learning, humans will be skilled at maximizing their skills in using reason, thoughts and creative ideas in making something that can produce value (Dwi Etika et al., n.d.). The National Education Association (NEA) defines media as all objects that can be manipulated, seen, heard, read or talked about along with the instruments used for these activities. Meanwhile, according to (Jablonka, 2002), the term media is defined as "the term refers to anything that carries information between a source and a receiver". (Amka, 2018) said that learning media can be defined as physical and non-physical tools that are deliberately used as intermediaries between teaching staff and students in understanding learning material so that it is more effective and efficient, so that learning material is received more quickly by students. intact and attract students' interest in learning further. According to (Tarbiyah & Palopo, n.d.) learning media has a function, namely as a component containing learning messages to be conveyed to students. According to (Jauhari, n.d.) explains that interactive multimedia is multimedia that is equipped with a controller that can be operated by the user so that the user can choose what they want for the next process. Meanwhile, according to (Brown & Merrill, 2011) STEM is a meta-discipline at the school level where science, technology, engineering and mathematics teachers teach an integrated approach and each disciplinary material is not divided but is handled and treated as a dynamic unit. (Kelley & Knowles, 2016) said that integrated STEM education is an approach to teaching two or more STEM fields by involving STEM practices in connecting each STEM field in order to improve student learning. The aim of STEM-based learning is also to make students have a balance between hard and soft skills, and have creativity (Grahito Wicaksono, 2020). Another benefit specifically found through integrated STEM education is developing students into better problem solvers, innovators, inventors, independent, logical, and technologically literate (Bozkurt Altan & Ercan, 2016).

STEM integration denotes an educational program in which students are given the opportunity to use their knowledge of science and mathematics to develop technological tools by participating in engineering practices, thereby supporting their meaningful learning process (Moore & Smith, 2000). Computational Thinking was first introduced by Seymour Papert in 1980

and re-stated by Jeannette Wing in 2006 with a slightly different version. Computational Thinking is a series of activities used to solve a problem by taking an approach, designing a system, and understanding human behavior based on fundamental concepts of computing so that it can find a solution to the problem, the solution is represented in a form that can be carried out effectively by information processing agents (Wing 2006, n.d.). The four computational thinking skills demonstrated by the Google company according to (Konstan et al., n.d.), namely Decomposition, Pattern Recognition, Abstraction, and Algorithms.

The Problem Based Learning Model (PBM) was adopted from the English term Problem Based Instruction/Problem Based Learning which was known during the time of John Dewey. (Saputra et al., 2019) PBM is a problem-based learning model where there is an interaction between stimulus and response, it is a two-way relationship between learning and the environment, while the brain's nervous system functions to interpret the help effectively so that the problems faced can be solved. investigated, assessed, analyzed and searched for problems properly. Problem-based learning technology is not only used in higher education, but also in teaching students in secondary schools (Ugli, 2020). (Gantang Pendidikan & Matematika, 2016) Problem-based teaching is an effective approach for teaching higher order thinking processes. This learning helps students to process ready-made information in their minds and construct their own knowledge about the social world and their surroundings. This learning is suitable for developing basic knowledge and complex knowledge. The syntax for using problem based learning includes orienting students to problems, organizing students, guiding investigations, developing and presenting work results, and analyzing and evaluating the problem solving process. PBL activities help students understand more than just concepts; they will gain an understanding of how, and why, to use the concept. This learning is suitable for developing basic knowledge and complex knowledge. The syntax for using problem based learning includes orienting students to problems, organizing students, guiding investigations, developing and presenting work results, and analyzing and evaluating the problem solving process. PBL activities help students understand more than just concepts; they will gain an understanding of how, and why, to use the concept (Hirça, 2011).

Research conducted by (Khairani et al., 2023) stated that the learning outcomes studied showed an increase after using STEM-based interactive multimedia, namely from the initial data received with an average value of 71.66 to 87.16. Meanwhile, from research conducted by (Pramono et al., 2022), the learning outcomes of students who applied STEM in interactive multimedia obtained very good results, namely 77%. Then research conducted by (Chen et al., 2022) showed that the use of motion media and computational thinking in practical dessert making courses can improve student learning outcomes. The average post-test score is higher than the average pre-test score. And the results of (Marina Angraini, 2022b) is that the use of interactive multimedia in learning can improve students' computational thinking skills. From the two-way ANOVA test carried out, a significance value of $0.001 < 0.05$ was obtained. This shows that there is an increase in the mathematical computational thinking abilities of students who receive learning using interactive multimedia-based teaching materials based on initial mathematical abilities. This spurred researchers to combine STEM and Computational Thinking in interactive learning media for research in educational units.

RESEARCH METHODOLOGY

Research design is an experimental design, so that the data (information) needed regarding the object in research can be collected actually. In this research, a One-Group Pretest-Posttest Design was used, which means that the research was only carried out on one group, it could be said that there was only a class, namely the experimental class. Sugiyono (2009, p. 83) says that One-Group

Pretest-Posttest Design is an experimental design that is only applied to a group by giving pretest treatment to determine initial abilities, then giving treatment and then posttest so that accurate scores will be obtained because they can be compared with before being given treatment. This design can be described as follows:

O1 X O2

Information :

O1 : pretest value (before treatment)

X : treatment (use of interactive multimedia)

O2 : posttest score (after being given treatment)

The participants used in this research were class VII of SMPN 1 Batujajar. The research carried out in this study was located at SMP Negeri 1 Batujajar which is located at Jl. No. Middle School 12 West Batujajar, Batujajar District, West Bandung Regency, West Java Province. The researcher used a non-random sampling technique, thus the researcher took samples from class VII D at SMPN 1 Batujajar with a total of 32 students. In the research conducted there are two types of variables, namely independent variables and dependent variables. The pattern (description) of the relationship between these two variables is:

$$X \text{ -----} > Y$$

r

r = Coefficient of variable X against Y

X = Dependent variable

Y = Independent variable

Based on the description that has been described, the researcher said that the influence of interactive multimedia with the Computational thinking-based STEM approach is the independent variable, while student understanding is the dependent variable. Researchers collected research data using several statements given to respondents in the form of a questionnaire. The type of questionnaire used by researchers is a closed questionnaire because all statements have been given alternative answers where students are directed to choose one of the alternative answers that have been provided. This questionnaire is used by researchers to measure the level of success in using learning media used in research in experimental classes. A test is an instrument or tool that can be written or verbal, the aim of which is to obtain information to measure students' abilities in an aspect. Researchers use this instrument as a measure of students' level of knowledge and understanding regarding the material studied through pre-test and post-test. The research procedures used are stages of the multimedia life cycle, Munir (2012) stated that the Comprehensive Life Cycle is divided into 5 phases, namely the analysis stage, design stage, development stage, implementation stage and assessment stage. Next, the researcher carried out data analysis which included validity testing, reliability testing, normality testing, gain testing, hypothesis testing and measuring student responses.

RESULTS AND DISCUSSIONS

The results of the researchers' findings as well as potential weaknesses arising from the research. Research is carried out by validating materials and media by experts in the field. In validating the assessment material, there were 10 items, the assessment criteria were 47 out of a maximum score of 50, when presented, it was 94%, which means the material is suitable for use with several notes on improvements that must be made. Validation of the assessment media with 8 assessment criteria items is 34 out of a maximum score of 40, when presented, it is obtained 85%, which means the material is suitable for use. Then the validation test of the questions that will be tested results in a score of 82% being found in the valid category, so that the questions can be used in research.

Most of the questions carried out in the validation test had an rpbi value above 0.482, namely 15 questions were valid and 6 questions were invalid. The test was analyzed using RStudio.

```
> #Uji Validitas Variabel X
> validitas(variabel_x, jumlah_variabel_x, 0.05)
  r hitung r tabel Hasil Uji
1  0.72475675 0.482146 Valid
2  0.12721794 0.482146 Tidak Valid
3  0.67926626 0.482146 Valid
4  0.49534252 0.482146 Valid
5  0.49534252 0.482146 Valid
6  0.24887941 0.482146 Tidak Valid
7  0.61952005 0.482146 Valid
8  0.58770180 0.482146 Valid
9 -0.53203573 0.482146 Tidak Valid
10 0.49050991 0.482146 Valid
```

Figure 1. Validity test

After carrying out validation testing, a reliability test is then carried out. The results of reliability testing of questions carried out using the Kuder-Ricahrdson Formula 20 (KR-20) coefficient obtained a figure of 0.863 in the "very good" category.

```
> #Uji Reliabilitas Variable X
> reliabilitas(variable_x, jumlah_variable_x)
Alpha Cronbach = 0.8630293 maka indikator-indikator penelitian Sudah Reliabel
>
```

Figure 2. Reliability test

Data on student results before treatment is obtained from pretest results which have previously been validated by material experts. Treatment is carried out once and then at the next meeting a test is carried out again, called the posttest. The questions used were 20 questions, of which 15 questions were the result of judgment by material experts and the other 5 questions the researchers took from free questions which have been validated internationally to increase capacity in computational thinking. The questions given are multiple choice. The results of the values obtained through comparison before and after treatment can be seen in table 4.11.

Table 1. Descriptive analysis results before and after treatment

	N	Minimum Value	Maximum Value	Average	Standard Deviation
Pretest	32	35	70	50.47	7,658
posttest	32	70	100	84.22	10,248

The scores obtained before treatment were obtained with a minimum score of 35, a maximum score of 70, an average score of 50.47 and a standard deviation of 7.658. Meanwhile, the score obtained after treatment was obtained with a minimum score of 70, a maximum score of 100, an average score of 84.22 and a standard deviation of 10.248.

The research carried out can be visualized in the following flowchart:

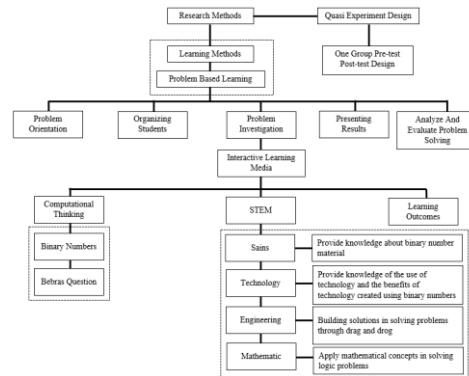


Figure 3. Flowchart on the stem approach, computational thinking, and problem based learning

Apart from that, the researcher also made a flowchart that the researcher used in carrying out multimedia learning as follows:

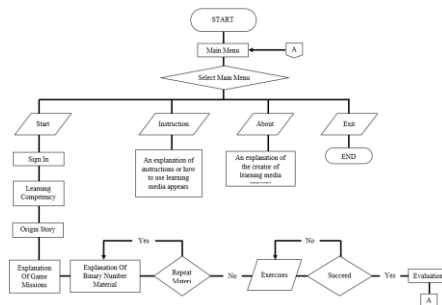


Figure 4. Flowchart in interactive multimedia

Apart from flowcharts, researchers also make storyboards as an illustration of the multimedia that will be created.

Table 2. Storyboard stages of STEM approach in interactive media

No	STEM in storyboarding	STEM in interactive multimedia	Stages shown in multimedia
1	Science 	Science 	In this scene, multimedia shows the simulation room and knowledge of binary numbers in implementation in everyday life, namely the use of light switches that are powered by electricity which causes the effect of electricity turning off and on.
2	Technology 	Technology 	In this scene, it is conveyed that lighting technology continues to develop, and its use in everyday life. The example presented is the use of incandescent light and traffic light technology through simulation and animation.
3	Engineering 	Engineering 	In this scene, multimedia presents problems that will be engineered by students using binary numbers to solve problems in converting decimal numbers to binary numbers.
4	Mathematics 	Mathematics 	In this scene, multimedia presents several pages related to mathematics. Where in several scenes material and problems related to numbers and logic as well as concepts about binary numbers are presented.

Furthermore, the research carried out the creation of interactive learning multimedia using the construct2 application.

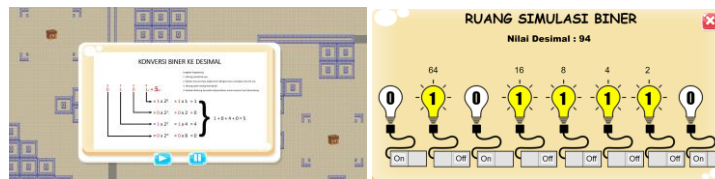


Figure 5. Draw an explanation page about binary using an interactive video and simulation image of binary number material

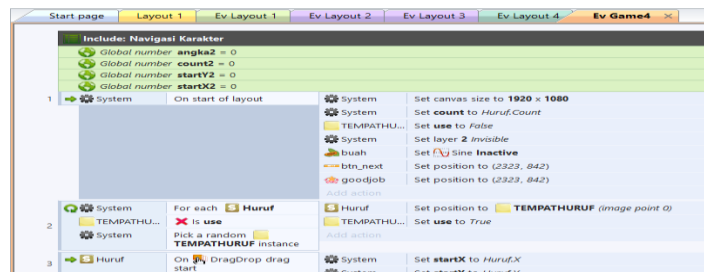


Figure 6. Some coding is used as an interactive multimedia program

In the follow-up discussion, namely data processing analysis of pretest, posttest, normalization test, t-test, and gain value.

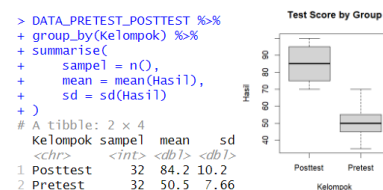


Figure 7. Result pretest posttest score

The results of the comparison of pretest and posttest scores can be seen that there is an increasing difference in student learning outcomes when using interactive learning multimedia with a STEM approach based on computational thinking. This is of course a concern that this learning multimedia has a big influence on student learning outcomes.

```
> normalitas <- with(DATA_PRETEST_POSTTEST, Hasil[Kelompok == "Posttest"] - Hasil[Kelompok == "Pretest"])
> df = data.frame(normalitas)
> View(df)
> shapiro.test(normalitas)

Shapiro-wilk normality test

data: normalitas
W = 0.96433, p-value = 0.359
```

Figure 8. Normality test

The results obtained from the analysis that has been carried out are the Wcount value of 0.96433 with a p-value of 0.359 > 0.05, so accept H0 and it can be concluded that the results of the analysis are normally distributed so that they meet the assumption of normality.

```

> t.test(Hasil~Kelompok, data = DATA_PRETEST_POSTTEST, paired = TRUE)

Paired t-test

data: Hasil by Kelompok
t = 19.248, df = 31, p-value < 2.2e-16
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 30.17381 37.32619
sample estimates:
mean difference
      33.75

```

Figure 9. Paired t-test

The results of the analysis calculations carried out in RStudio showed that the average difference was 33.75. Then the range above and above at a 95% confidence level is 30.17381 to 37.32619, then the t-count result is 19.248 and the p-value is $2.2 \times 10^{-16} < 0.05$. So from the results of these calculations H1 is accepted, which means that the difference in average learning outcomes between the pretest and posttest is significant or meaningful.

```

> print(Gain_Score, n=33)
# A tibble: 32 x 5
  Sampel  Pretest Posttest Gain_Score Kategori
<chr>    <dbl> <dbl> <dbl> <chr>
1 Siswa1      65     100      1 Tinggi
2 Siswa2      45     95      0.909 Tinggi
3 Siswa3      40     95      0.917 Tinggi
4 Siswa4      50     80      0.6 Sedang
5 Siswa5      55     70      0.333 Sedang
6 Siswa6      55     85      0.667 Sedang
7 Siswa7      55     85      0.667 Sedang
8 Siswa8      70     95      0.833 Tinggi
9 Siswa9      45     70      0.455 Sedang
10 Siswa10     55     100     1 Tinggi
11 Siswa11     35     75      0.615 Sedang
12 Siswa12     45     80      0.636 Sedang
13 Siswa13     55     80      0.556 Sedang
14 Siswa14     55     85      0.667 Sedang

```

Figure 10. Gain t-test

Analysis results:

Mean Pretest : 50.47
 Mean Posttest : 84.22
 N-Gain Score : 0.6814
 N-Gain Score (%) : 68.14%
 N-Gain Score Category : Currently

CONCLUSION

This research raises the topic of combining STEM with computational thinking in student learning in the classroom using interactive multimedia. Validation of multimedia-related instruments and validation of the questions used are tested first by experts in the field before being tested on students in the field. The results showed that the assessment was quite high and this shows that the multimedia used in general is very good for use in research. The results of the validation of the question instrument show that the evaluation instrument that will be used is an effective tool in measuring research results. The application of interactive multimedia with a STEM approach based on computational thinking has a significant impact on student learning outcomes. There are very clear differences in student learning outcomes before and after the intervention. An increase in maximum and minimum scores also indicates an improvement in student learning outcomes. The hypothesis states that there is an influence of the application of interactive multimedia with a STEM approach based on computational thinking on student learning outcomes. This research can be a benchmark for further research in efforts to improve student learning outcomes through identifying interactive multimedia preferences with a STEM approach based on computational thinking. As well as implementation that can be applied to improve other variables so as to increase the usefulness of interactive multimedia in the field of education.

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