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Digital Storytelling (DST) Media Development in Online Physics Learning Based on Computational Thinking

[1]Kristian Dinata

[1] SMAN 2 Bengkulu Selatan, Indonesia
kristiandinata@sman2bengkuluselatan.sch.id

Abstract

The objectives of the study are: (1) producing learning media as a component of computational thinking learning; (2) describing the effectiveness of the thinking process based on DST media of online Physics learning; (3) describing user response based on computational thinking. The type of study is "Research and Development" by the ADDIE model. The data of the study were taken from: (1) the analysis of the data from students of X class in the period 2020/2021 and curriculum document of Physics material; (2) expert validation which are lecturers and Physics teachers of SMAN 2 South Bengkulu; and (3) test source from students of X class. There were 32 students of MIPA 4 (experiment class) and 33 students of MIPA 5 (control class). The methods of the study were observation, questionnaires, and tests. The analysis of the study was qualitative and quantitative method. The results of the study showed that: (1) expert validation was stated that some components of the learning process based on computational thinking such as syntax component, social system, principal reaction, support system, instructional effect, and accompaniment impact. Each of them is valid; (2) Based on the Quasi experiment, there was a significant difference between the learning outcomes using experiment test and control test (grade t count is 2.876 in other hand grade t table in 5% and grade $p<0.005$ is 2.042); (3) the students' responses from learning computational thinking were very positive (95%) and positive (5%). The conclusion is computational thinking learning is a valid product model, practice, effective, and suitable to be used.

Keywords: computational thinking; DST; media development; online Physics learning

Introduction

The application of the National Assessment in Indonesia has changed the paradigm of education, especially in the learning process. The National Assessment (AN) was officially implemented by the Ministry of Education and Culture and the National Examination. This is based on PISA research, and it is proved that the students' abilities in primary and secondary education are inadequate. In 2018, around 70% of students had a literation competency below the minimum standard. Similar to Math and Science skills, 71% of students were below the minimum competence for Mathematics and 60% for Science (Kemdikbud, 2021). Indonesia's PISA score has been stagnant for the last 10-15 years. This condition causes Indonesia to become one of the countries that is consistent with the lowest PISA level.

The learning process should be able to increase students' reading and numeracy skills because there are relationships between National Assessment in the 21st-century skills and the measurable Pancasila student profile through the National Assessment in the form of Minimum Competency Assessment (AKM), Character Survey, and Learning Environment Survey. There are three concepts of Education and Culture in Indonesia to develop curriculum for primary and secondary school levels, which are 21st-Century skills (Fadel, 2009), scientific approach (Dyer, 2009), and authentic learning or authentic assessment (Wiggins, 2011). Furthermore, the three concepts are adapted to create Indonesia's creativity in 2045. Indonesia's creativity is supported by research that shows a shift in work in the future. The future job pyramid shows that the highest type of work is creative work. Meanwhile, the future work routine will be taken by robotic and automatic technology. Creative work needs human intelligence and creativity to produce creative and innovative products.

Physics is one of the subjects taught at SMAN 2 South Bengkulu. This is a difficult subject for students. This subject emphasises concepts and calculations containing many formulas or equations. The first observations at SMAN 2 South Bengkulu showed that: (1) the material was taught by expository and lecture methods; (2) the students should memorise all the concepts and equations; (3) the teacher explained about solving practice questions and did not apply innovative learning models and media; (4) the material was not in line with the daily life activities (not contextual); (5) the teacher was more active than students, while students only listened, took notes, and completed UKBM (distance-learning worksheets); and (6) the students were lack of motivation: they did not participate in the learning process which resulted in lower outcomes.

The students of SMAN 2 South Bengkulu are currently the generation born in the Z-generation range (between 1996-2010) who have the challenge of being able to synergize with the rapid technological disruption. In a matter of years, advances in applied technology have changed the form of social order. To deal with this change, the skills required are becoming increasingly complex. Cognitive abilities are no longer the only strength of human being; however, literacy, numeracy, and character analysis skills must also be possessed. Generation Z of SMAN 2 South Bengkulu currently demands a system and teaching methods that is suitable for their social character. One of the efforts to face these obstacles is the development of DST media in online Physics learning based on computational thinking.

DST (Digital Storytelling) media is a combination of multimedia features in storytelling, such as digital graphics, text, voice narrative recordings, videos, and music that presents certain material within a certain duration of time using digital format (Dreon, 2011). Digital Storytelling (DST) is an alternative that can be implemented to process digital content. DST is not only moving the art of storytelling into a multimedia format containing images, videos, and audio using certain applications. Some experts claim that digital storytelling is a modern expression of ancient art in storytelling. Physics learning has a lot of material that is contextual in nature. Some materials are sometimes considered to be difficult; however, DST can help students in understanding the materials by searching for information so that students can be eager to learn them.

The determination of Higher-Order Thinking-oriented Physics learning activities reflects the basic strategy of computational thinking. It is more emphasised in the skills of abstraction, algorithms, decomposition, and pattern recognition so that students get used to it. In one learning activity, there can be one or more basic strategies for computational thinking (abstraction, algorithms, decomposition) (Wing, 2008; Wing, 2017a; Wing, 2017b). These four basic strategies are not a sequence of stages, but components of the basic strategies used to develop CT skills. In one learning model, these four basic strategies must be present and applied in their activities; but in one activity, the basic strategy does not need to be fully applied. Meanwhile, computational thinking is described as a thought process in formulating and solving problems computationally through computers, humans, or machines (Wing, 2006). The goal of computational thinking process is that students can apply the skills of abstraction, algorithms, decomposition, and pattern recognition.

The development of DST media in online Physics learning based on computational thinking facilitates students to discuss the content and makes them understand the concept of Physics lessons based on four basic strategies in computational thinking, for example, decomposition, pattern recognition, abstraction, and algorithm. Decomposition describes complex problems of the students or simpler problems system. Pattern recognition means students are sorting out and grouping the same pattern of problem. Abstraction means when students focus on the important things, but they consequently ignore the unimportant and irrelevant things. Meanwhile, the algorithm means the students solve a problem in systematic ways with SMART (Specific, Measurable, Attainable, Relevant, Time-based). The following points are the advantages of using digital media for teaching and learning process: (1) increasing students' concentration up to six times; (2) increasing students' interest in learning and analysing (especially study objects or simulations); (3) increasing savings on laboratory costs and teaching simulation media (savings can be more than 70%); (4) improving the connection of teachers and students through technology; and (5) helping teachers to conduct HOTS simulations. The idea of developing DST media in online Physics learning based on computational thinking is designed to make Physics learning become more contextual, interesting, meaningful, full of characters, and put concern on the environment so that it has an impact on increasing the competence of students.

Methodology

2.1 Research Approaches and Methods of The Study

This is a development research which aims to produce digital media in online Physics learning based on computational thinking. The product to be developed consists of several components, such as learning media, social systems, reaction principles, support systems, instructional and accompanying impacts, online Physics instructional products based on computational thinking, as well as an evaluation system to get information based on the real conditions. *Research design*

The development media which is used in this research is the ADDIE model. The ADDIE model stands for Analysis, Design, Development or Production, Implementation or Delivery, and Evaluations.

Picture 1.1. *Research Procedure Using the ADDIE Model (Dick, 2001)*

2.2 Research Settings

The place of the study was SMAN 2 South Bengkulu, while the time of study was in the even semester of the 2020/2021 school year and in the odd semester of the 2021/2022 school year. The research period started from March to the fourth week of August 2021. *Population or sample (unit of analysis)* The subjects in this study were experts, students, and teachers. The experts are people who can provide valid data and content, such as linguists as well as experienced lecturers and teachers. The students are those who can provide data about the practicality and effectiveness of the model, which are Class X (IPA 4 and IPA 5) SMAN 2 South Bengkulu which consist of 64 students. The analysis of the study used random sampling.

Table 1.1 *Detailed Overview of Experiment and Control Classes*

Class	Amount Student (person)	Year Sign in	Gender (person)	Teacher	Subjects
Experiment (MIPA 4)	31	2020	L = 12 P = 20	Kristian Dinata, S.Si	Physics
Control (MIPA 5)	33	2020	L = 14 P = 19	Kristian Dinata, S.Si	Physics

2.3 Technique and Data Collection

The methods of this study were documentation, questionnaires, interviews, and observation.

a. Documentation Method

The documents derived in this study were from Physics learning of X class of SMAN 2 South Bengkulu students, research data, and during the implementation of research activities.

b. Test Method

The test of the study is an objective test using multiple choices method with five answer choices, totalling 30 items. The multiple-choices test was chosen to measure all the learning objectives and reduce the chance of guessing by students because the answer choices are more than two. The multiple-choices test was applied to determine the learning outcomes of the students in both experimental and control groups when the pre-test and post-test were carried out.

c. Observation Method

The study used an observation method which the object has been determined previously. The aim of observation is to implement the digital media in online Physics learning based on computational thinking. This observation consists of the implementation of computational thinking in online Physics learning using digital media and not (only using conventional models). An observation guide in the form of checklist was applied and divided into 4-point Likert scales.

d. Questionnaire / Questionnaire Method

This study used a closed questionnaire with a Likert scale that should be answered according to the 4 predetermined answer choices, which are strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD). Respondents only put a checklist on the questionnaire given. The questionnaire was given to media experts, learning material experts, and students.

2.4 Analysis of The Data

a. The Data Analysis of The Planning Model

The research data on the planning/learning instrument was carried out by analysing a questionnaire that had been validated by the instructional media and material experts through validity construction. The validation instrument was arranged in a Likert scale with the following details: (a) Very Good (SB) with a point of 4; (b) Good (B) with a point of 3; (c) Not Good (TB) with a point of 2; and (d) Very Not Good (STB) with a point of 1 (Sujana, 2005). After that, the results of the validation media were converted into the following interpretations.

Table 1.2. *Learning Media Planning Conversion Rate*

Number	Average score	Interpretation
1.	3,01 – 4,00	Very valid
2.	2,01 – 3,00	Valid
3.	1,01 – 2,00	Invalid
4.	0,00 – 1,00	Very invalid

b. The Analysis of Practicality Learning Model Data

The analysis of the data was taken from the observation and documentation based on teacher's questionnaire. The questionnaire used the Likert scale with the criteria: (a) Very Good (VG) with a point of 4; (b) Good (G) with a point of 3; (c) Not Good (NG) with a point of 2; and (d) Very Not Good (VNG) with a point of 1. Then, the results of the practicality test for the Learning Model were converted.

Table 1.3. *The Practicality of Learning Media Conversion Rate*

Number	Average score	Interpretation
1.	3,01 – 4,00	Very worthy
2.	2,01 – 3,00	Well worth it
3.	1,01 – 2,00	Not feasible
4.	0,00 – 1,00	Not feasible

c. The Analysis of Student Learning Outcomes Data

The development of implementation stage using digital media in online Physics learning based on computational thinking was carried out using a pre-test and post-test random control group pattern. This pattern was designed by taking a sample of subjects involving a control sample as a comparison. Each sample subject was subjected to two treatments, namely before the implementation of learning (pre-test) and after the learning process (post-test). The experimental design of the pre-test and post-test random control group pattern could be described in the following table.

Tabel 1.4. *Experimental Design*

Group	Technique Taking	Pre-test	Treatment	Post-test
E	R	O_1	X	O_2
K	R	O_3		O_4

d. Student Response Questionnaire Data Analysis

The data analysis of the student questionnaire was in a descriptive percentage in order to make it easier to be read into tables. This analysis used qualitative criteria applying Likert scale with positive and negative statements based on the opinion (Sudjana, 2005), so that the positive statement got the highest point with the following details: (a) strongly agree (SS) with a point of 4; (b) agree (S) with a point of 3; (c) disagree (TS) with a point of 2, and (d) strongly disagree (STS) with a point of 1.

Table 1.5. *Student Response Conversion Rate*

Number	Average score	Interpretation
1.	3,01 – 4,00	Very positive
2.	2,01 – 3,00	Positive
3.	1,01 – 2,00	Not positive
4.	0,00 – 1,00	Not very positive

Results and Discussion

Computational thinking-based learning is a series of learning approaches, strategies, methods, techniques, and tactics which is described from the beginning to the end of the learning process. The following are the characteristics of computational thinking-based learning.

1) The learning approach using trials and implementation based on computational thinking is a student-centred and scientific approaches which have four basic strategies in computational thinking (decomposition, pattern recognition, abstraction, and algorithm).
2) The learning strategy contains planning. The learning strategy in this study is discovery-based learning through discussion and games. The learning method used is a variety of methods, ranging from discussions, presentations, lectures, and games both individually and in groups.
3) The learning technique is the way teacher applies the learning method. In the discussion, for example, the teacher applies a rotating technique where each group does the presentation while the other groups give the responses.

In the 21st-Century, all the aspects are controlled by science and creativity. The massive changes in economic world and the internet have realised Indonesian people that they should change their mindset on education for preparing the golden generation. The ability to compete with other countries depends on the quality of education in order to prepare excellent students. 21st-Century learning requires Indonesian students to learn to know, learn to do, learn to be, and learn to live together. (Fadel, 2009) suggests three important aspects in facing the 21st-Century, which are “4C” learning and innovation, digital literacy skills, as well as life and career skills.

Table 2.1. *21st Century Skills*

Learning and Innovation “4C”	Digital Literacy	Life and Career Skills
Critical thinking & problem-solving	Information of literacy	Flexibility and adaptability
Creativity & innovation	Media literacy	Initiative and self-direction
Communication	ICT Literacy	Social and cultural interactions
Collaboration		Productivity and accountability
		Leadership and responsibility

To answer the challenges of the 21st-Century, students need to master several Higher-Order Thinking Skills, such as critical thinking, creative thinking, problem-solving, and decision-making (Brookhart, 2010). Magazine *21st Century Skills, Education & Competitiveness: A Resource and Policy Guide* (2008) stated that there were several actions needed in facing and preparing the 21st-Century generation: critical thinking and making decisions; solving complex, cross-sectoral, and infinite problems; creativity and entrepreneurial thinking; communicating and collaborating; making innovations using knowledge, information, and opportunities; as well as safeguarding financial, health, and public responsibility.

The basic strategy of computational thinking is reflecting the Higher-Order Thinking activity in Physics learning. Computational thinking is not programming but a basic skill in one's thinking that can be applied in all fields, including Science. With this skill, it is hoped that students can formulate and solve problems as a provision to face challenges of the 21st-Century (Cansu, 2019; ISTE, 2011; McNicholl, 2018; Yadav, 2014). In applying computational thinking, students do not have to use digital media technology. However, because of the challenges in the digital era, they must be exposed to the digital world in the field of information and communication technology. Thus, students need to be familiar with the learning process integrated with the use of digital media technology. A variety of digital tools can be utilised based on the learning objectives to facilitate the learning process and to assist students in their problem-solving processes.

1) Steps to develop DST media based on computational thinking

Computational thinking-based learning is a new learning model to improve the competence of students. This learning model is designed according to the needs of students and demands. The steps in developing computational thinking-based learning derive from the ADDIE model development research (Analysis, Design, Development, Implementation, and Evaluation).

The implementation of model development was carried out in two classes, which were class X MIPA 4 (experimental class) and X MIPA 5 (control class). The number of samples from the two classes was 64 students. In class X MIPA 5, conventional and lecture methods were applied with questions and answers session. Meanwhile, class X MIPA 4 applied DST media development in online Physics learning based on computational thinking. After being given treatment, both classes were given a post-test. The data obtained were analysed by using independent sample T-test statistics. However, before the t-test, the prerequisite tests were carried out (normality and homogeneity). From the results of the normality test, it was found that the student learning outcomes data were normally distributed. Then, the homogeneity test was carried out using the Lavene Test on the pre-test scores of both classes. The results of the homogeneity test are shown as follows.

Table 2.2

Levene Statistic	df1	df2	Sig.
,006	1	62	,940

The data showed p-value = 0.940 > 0.05, then the data of the two classes were homogeneous. Then, the independent sample t-test was conducted to test whether there was an effect of DST media development in online Physics learning or not on student learning outcomes. Here are the results of the t-test.

Table 2.3. *Group Statistics*

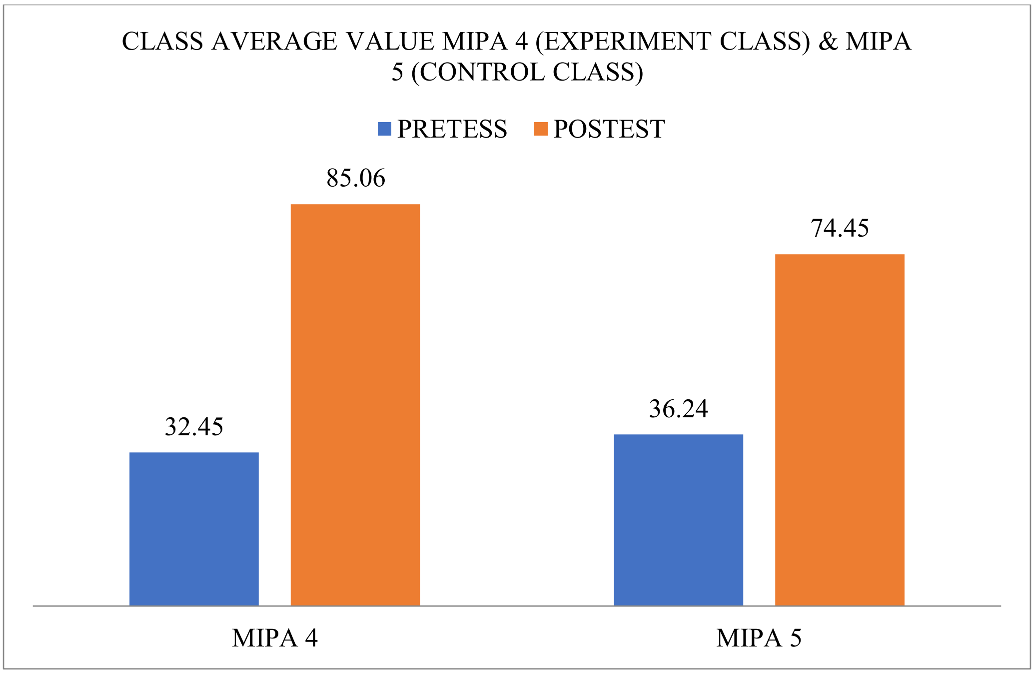
Class	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Value Class X MIPA 4 Class X MIPA 5	**31 33**	**85,06 45 74,45 45**	**9,47254 18,36963**	**1,70132 3,19774**

Table 2.4. *Independent Samples Test*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Value	Equal variances assumed	13,484	,001	2,876	62	,006	10,60997	3,68946	3,23484	17,98510
	Equal variances not assumed			2,929	48,532	,005	10,60997	3,62216	3,32919	17,89075

The t-count for class X MIPA 4 (experiment) was 2.876. The t-table was valued at the 5% significance level and the p value < 0.05 was 2.042. Because of the value of t-count > t table, there was a significant difference between the learning outcomes of students with DST media development and those who were taught using conventional models on compound nomenclature.

Therefore, it can be concluded that the learning outcomes of students taught with DST media development are better than those who being taught by conventional method. This result is supported by the mean of the pre-test and post-test results of the two classes which is illustrated by the following graph.



Picture 2.2. *Graph of Average Value of Experiment and Control Class*

Problems, learning needs and requirements through interviews, questionnaires and direct observation were identified at the Analysis step. At the Design step, learning objectives were formulated and several items were designed: (1) the syntax concept of the learning model; (2) social systems; (3) reaction principles; (4) support systems; (5) instructional and accompaniment impacts; and (6) the learning media used to support the developed syntax model. After that, all of these components were validated by several expert teachers and lecturers to determine the feasibility of learning instruments based on computational thinking. Next, a limited trial was conducted by applying the learning model in IPS 3 class consisting of 32 students to find out some issues that needed to be fixed and improved. In this step, computational thinking in Physics learning was implemented in MIPA 4 class. Meanwhile, conventional learning models were applied in MIPA 5 class. In the Evaluation stage, the effectiveness of learning model was evaluated as the final revision after dissemination.

2) The effectiveness of DST media based on computational thinking

The effectiveness of computational thinking-based learning products using DST media could be seen from the increase of student learning outcomes in the experimental class (MIPA 4). A statistical test was required in both classes. The results of the paired sample t-test showed that there was a significant difference between computational thinking-based learning and experimental class learning. Meanwhile, the control class utilised conventional learning models. This showed that the application and implementation of computational thinking-based learning could improve student learning outcomes.

The effectiveness of computational thinking-based learning in improving student learning outcomes are as follow: (1) Computational thinking-based learning is able to encourage students to be actively involved in learning by providing contextual phenomena (the phenomena of real events in daily life); (2) The seriousness of students' learning is balanced with the experience of fun activities through integrated discussions and games to find the concept of cooperation-competition. In-class cooperative-competition strategies, implementation of team projects and problem-based learning are essential in seizing opportunities for experienced learners to learn; (3) Computational thinking-based learning provides more time for students to think about why teachers ask them about the phenomena related to learning and to seek for the information from various sources at the stage of reading literature; (4) Computational thinking-based learning is constructivist in which students build their knowledge through fun activities (games) so that the problem-solving in the final stage will be easier. This is in line with the opinion of Durkin and Barber (2002) that the use of games in general learning provided a learning atmosphere that motivated students to be involved in it and had a pleasant effect on those involved in learning. In addition, computational thinking-based learning also requires teachers to be active and creative in thinking about learning designs that are attractive to students, for example, deciding the objects that should be brought by students and the types of games that are suitable with the characteristics of materials and students.

The implementation of Physics learning based on computational thinking from the trial phase and the implementation stage accompanied by revisions show that there are several activities that must be carried out by the teacher. First, the teacher must create a learning atmosphere that can make all students get involve in the contextual phenomena. Phenomena must be presented as attractive as possible through storytelling technique, video, or interesting illustrative images. Second, the teacher must be patience and allow students to think and discuss in analysing phenomena and making questions based on the phenomena given. Third, the teacher must be able to conclude various kinds of students' questions into one or more general questions that can accommodate all the questions of students. One thing that needs to be considered by the teacher is to ensure that all students' questions have been accommodated so that students can focus on the learning process. Fourth, teachers must plan and prepare all sources of literacy. Fifth, the teacher must determine the types and rules of the game and integrate them with discussions containing constructivist questions. Sixth, the teacher should be able to guide students in solving problems and making conclusions.

3) The response of teachers (media users) and students to learning based on computational thinking assisted by DST media

The results of the observations showed that students' responses were in the form of prominent activities. After that, the activities were described as instructional and accompaniment impacts. These instructional impacts have the purpose of increasing the ability of students in several ways, such as: observing phenomena; asking questions; literacy; building concepts; assessing; solving problems; drawing conclusions; and Higher-Order Thinking skills (the emergence of higher order thinking questions). The accompanying impacts that arise during learning are collaboration skills, positive attitudes towards learning, independence or autonomy in learning, leadership skills, verbal skills, and honest attitudes as part of strengthening character education.

The students' responses were as follow: (1) Students were active, enthusiastic, and motivated to learn Physics using computational thinking-based learning; (2) Students strongly agreed that computational thinking made learning Physics more contextual or relevant in daily life; (3) DST media learning helped students to understand the concept and solve problems; (4) Computational thinking-based learning increased their creative communication skill and relationships with each other. Therefore, computational thinking-based learning is able to present a combination and integration of scientific approaches and 21st-Century learning skills. Based on the results of this study, computational thinking-based learning has met three quality criteria for learning models, namely: validity, practicality, and effectiveness.

Conclusion

Based on the results of the study, it is concluded that computational thinking-based DST learning media is developed using the ADDIE model containing syntax components, social systems, reaction principles, support systems, as well as instructional and accompaniment impacts. The results of the expert validation show that the supporting components of computational thinking-based DST learning media are consistent and related to each other. The results of a simple quasi-experimental study show there are significant differences between the experimental group and the control group (t count was 2.876 while t table was at the 5% significance level and $p < 0.05$ was 2.042). It means that there are significant differences between students which are taught using computational thinking-based learning and those who are taught using conventional models. There are positive (5%) and very positive (95%) students' responses to the computational thinking-based DST learning media.

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