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Development of a Simple Heat Learning Media to Enhance Students Science Process Skill

Kostan D. F. Mataubenu[1], Demeryati Langtang[2]

[1,2]Sekolah Tinggi Keguruan dan Ilmu Pendidikan Soe, Program Studi Pendidikan Fisika,
Jl. Badak No. 5A Lokasi II SMK Negeri 1 Soe, Indonesia

Abstract: ***This research aims to develop a simple heat learning media based on microcontroller ATMEGA8535 and examines its effectiveness and feasibility to enhance students' science process skill. This research conducted in three steps i.e., preliminary study, development and examination. Three expert on physics education and 51 students are involved in this study. The instruments used for collecting data are questionnaire and test. The instrument evaluated both quantitatively and qualitatively. Pretest and posttest are evaluated by paired sample t test of pre-experimental one group pretest-posttest. The evaluation of testing data confirms the effectiveness and the feasibility of the heat learning media.***

Keywords: heat, learning media, microcontroller ATMEGA8535, science process skill

1. Introduction

Science defined as human acts to answer their question about some phenomena through continually process. Scientist investigates natural behavior through construction, explanation, prediction of how the universe works, and tries to control physics' variables. This is a process that both continually and repeatedly [1]. The investigation of natural behaviors depends on several factors, i.e., science product, science process and science attitude. Attitude is the wonder of how a natural process occurs. Process is how science gained through scientific methods as formulating hypothesis, experiment, evaluation, measurement, and making a conclusion. Product is principle, theory and laws obtained from science process. Another important thing is how science can be implemented in human daily life [2].

Science process is an important skill should be owned by students who are learning physics as the part of science [3]. Science process skills are mainly classified as basic skills and integrated process skills. Basic skills are observation, classification, communication, measurement, prediction and drawing conclusion. Integrated process skills are controlling variable, formulating hypothesis, doing data interpretation and operational defining [4].

The development of technology has made student can easily obtain knowledge without doing a process or an experience. Nevertheless, the condition is bad for preparing students for their future [5] because of the students are accustomed to be user than to be producer [6]. Science learning process should support and raise the habit of students to explore how to get knowledge, how to produce knowledge and raise students' ability on problem solving [7] [8]. Someone who has science process skill has accustomed to solve problem with high critical thinking [9]. Therefore, enhancing students' science process skills is very important to be implemented in learning process.

Curriculum of Indonesian elementary and high school as recommended by Ministry of Education stated that learning process have to conducted in scientific method [10]. The curriculum allows the learning process focus on student rather than teacher. Teacher has to let student having learning experience as observing, questioning, experimenting, processing data and communicating. It means that curriculum 2013 focuses on science process skills especially in science learning process.

Learning media is an important thing in learning process [11] to help students raise their science process skill that indirectly support the success of curriculum 2013. The early researches have shown that learning media can improve learning results of students [12]. Students are attracted and motivated to learn science using learning media because it can help them to convert an abstract concept to be a concrete concept [13]. Likewise learning media is important to train student science process skill especially to conduct experiment and to identify variables [14].

Observation and interview have done toward teacher in several high schools in rural areas of East Nusa Tenggara, Indonesia. It has found that there are many schools have no learning media to support the learning process especially on heat topic. The problem caused learning process generally conducted in traditional method. Therefore, the comprehension and science process skill of students are hard to be reached especially in heat topic [15].

Based on the background stated above, the problem statements in this research are:

1) How to design and develop a simple heat learning media based on microcontroller ATMEGA8535 equipped with LM35 temperature sensor?
2) Is the heat learning media effective to train students' science process skills?
3) Is the heat learning media feasible for use in learning process?

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2. Literature Review

2.1 Science Process Skills

Science process skill is very important to learn and master for everyone. If one has mastered process skill, he/she has mastered necessary skill for higher learning level, namely conducting research and solving problems. Science process skills are distinguished into two groups: basic process skill and integrated process skill. Included in basic process skill are skills of observing, classifying, measuring, interfering, interpreting, communicating, and predicting. These skills by students in order to understand science. Curriculum 2013 of Indonesia conducted science process skills in learning process such as gathering information, observing, questioning, experimenting, and then processing the data, presenting data, or information, followed by analyzing, associating, and concluding [1][10].

2.2 Learning Media

Learning media is tool that used by teacher to help students understand a lesson. Learning media can be used to do experiment in learning science. Learning media can be used to clearly explain a science concept. Beside these, learning media also used to train science process skills [16].

2.3 Microcontroller Atmega8535

Microcontroller is a system consist of microprocessor, memory, input/output pin and data buss in a single chip. There are several kinds of microcontroller. Atmega8535 is one microcontroller that used in many experiment and research because it can work fast than other microcontroller. Microcontroller Amega8535 has 4 port with 40 pin input/output and analog to digital converter to convert analog to digital data. It can be operated using 5 Volt DC power. Atmega8535 can be programmed using C program designed in *CodeVision AVR* software. This device can be used to read LM35 temperature sensor the display it on the screen. Atmega8535 is low cost and easy to find so can be used for experimenting and training science process skills [17].

2.4 Heat

Heat is one form of energy. If an object receive or release energy, its temperature and phase will change. If an object absorb heat, its temperature will increase and vice versa. Heat which received or released by an object is proportional to its temperature change or mathematically written as following equation [18] [19].

$$Q = m.c.\Delta T \quad (1)$$

Q is heat (Calorie), m is mass (kg), c is specific heat number (calorie/kg^{0}C) and ΔT is temperature change (^{0}C).

Heat energy can be converted from electrical energy. An electric conductor with resistance R passed by electric current I during t, will need energy as equation (2).

$$W = VIt = I^2Rt \quad (2)$$

The electric energy converted to heat energy through the following equation.

$$I^2Rt = mc\Delta T \quad (3)$$

2.5 LM35 Temperature Sensor

LM35 is a small size sensor like a small transistor. This component can measure temperature up to 150^{0}C [17]. It has 3 pin: input, ground and output. Output of this sensor will increase 10 mV every temperature change 1^{0}C so the output voltage of LM35 due to equation (4).

$$V_{LM35} = \text{Temperature x } 10 \text{ mV} \quad (4)$$

3. Methods

3.1 Research Model

This research conducted in three steps i.e., 1) preliminary study; 2) design and development; and 3) examination. Preliminary study consists of literature study, field study and schematic design of heat learning media. Design and development cover designing the media, expert examine and product revision. Examination includes field examination and final product revision. Field examination aims to confirm the effectiveness and the feasibility of product (learning media) to enhance science process skill of students [20].

3.2 Population

This research involved three lecturers who are considered as experts in physics education and 51 students of senior high school. The instrument test had been given to 27 students before field examination to evaluate its validation. The instrument which had been validated then was used in field examination. Experimental one group pretest posttest was conducted in field examination. There were 24 Xth grade students of senior high school involved in this step. Three lecturers were involved to validate the questionnaire sheets, students' worksheets and content validation of instrument test. This research is under the topic of heat.

3.2.1Data Collecting

Data collection techniques used in this research are laboratory examination, questionnaire, and test. Laboratory examination is LM35 calibration and scientific examination purpose. Questionnaire is used to validate and to get the feasibility of heat learning media. The test is used to evaluate the effectiveness of heat learning media to enhance students' science process skill. The instrument test was formed based on science process skill indicators such as 1) observation; 2) planning experiment; 3) communicating; 4) formulating hypothesis; and 5) interpretating.

3.3 Data Analysis

The data obtained was analyzed both quantitatively and qualitatively. The validation questionnaires, students' worksheets, instrument test and student responses questionnaire were evaluated by counting the average scores in 4 categories: 1) valid; 2) valid enough; 3) less valid; and 4) not valid. The results of student responses questionnaire were

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evaluated by counting the average scores in four categories: 1) very agree; 2) agree; 3) less agree; 4) disagree. The results of pretest and posttest were evaluated based on paired sample t test because the treatment was conducted as class experimental one group pretest-posttest [20] [21].

4. Results and Discussion

4.1 Product Specification

Heat learning media was designed in such a way to get a learning media that can work based on digital electronic principles. The heat learning media was designed to help students learning heat and temperature. There were two part in designing the media i.e., hardware and software. Hardware of the media consists of input, process and output. Input consists of push button and LM35 temperature sensor. Process consists of microcontroller ATMEGA8535. Output consists of relay contact and LCD. The block diagram of the medias hardware is shown on Figure 1 below.

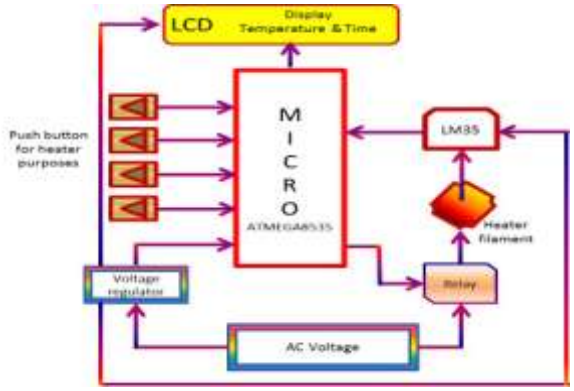

Figure 1: Hardware design

Figure 2: Result of hardware design

Software is the program for microcontroller ATMEGA8535. The program is created using C program. The C program was designed using compiler CodeVision AVR programmer. The program was created to access the registers of ATMEGA8535 as pins to configure them as input or output, ADC to convert analog data of LM35 to digital data, and timer to count time of heating [17]. The program must be synchronous with hardware so the total system can work properly.

Figure 3: Design of software in CodeVision AVR

Push button was used as signal input to ATMEGA8535 for working. While the button is pressed, the ATMEGA8535 will do a process. The process in ATMEGA8535 are reading temperature from LM35, start counting time, and opens the relay for electric current can flow to the heater filament. Temperature read by ATMEGA8535 then displayed with timer at the same time with electric current flow at the first time to heater filament. When the desired time is reached, the measurement of temperature and electric current will stop. LCD 2x16 characters is used to display temperature and timer. The system uses 12 V and 5 V DC current, so a power supply was designed in this research to meet this problem.

4.2 Laboratory and Expert Examination

Laboratory examination is conducted in two step i.e., LM35 calibration and scientific examination purpose to obtain the heat learning media validation. Calibration was done by comparing the measurement data of LM35 and standard thermometer. On the other hand, scientific examination purpose was conducted through experiment to prove the relation between Calorie unit and Joule unit. It is known that 1 Calorie $\approx$ 4.186 Joule or 1 Joule $\approx$ 0.239 Calorie [18] [19]. Linear regression was done to the measurement results of LM35 and standard thermometer. It was shown that the R^2= 0.9909 $\approx$ 1 means that there was a strong correlation between LM35 and standard thermometer. Whereas the scientific examination shown that 1 Joule $\approx$0.2449 Calorie. The data from experiment is close to the data of theory (0.2449 $\approx$0.239), so the heat learning media is valid based on the laboratory examination. The results of calibration and scientific examination are shown on Figure 4 and Table 1.

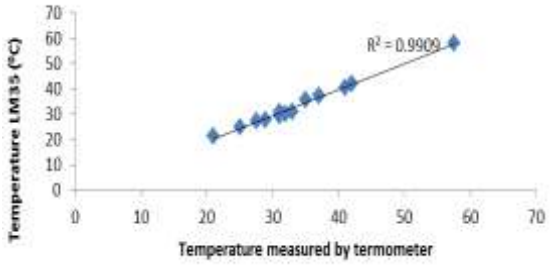

Figure 4: Comparison between thermometer standard and LM35

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Table 1: scientific experiment to prove the relation between Joule and Calorie

V=29,67, R=470 Ohm, m_{cal}=37,30 gr, c_{cal}=0,26 kal/gr^{0}C, m_{water}=90,43 gr, c_{water}=1kal/g^{0}C					conversion	
$\Delta T(^0C)$	t(s)	W (J)	Q_{cal} (cal)	Q_{water} (cal)	Joule	calorie
23.9-24.9	196	367.11	9.698	90.43	1	0.272748
24.9-25.9	238	445.77	9.698	90.43	1	0.224616
26.4-27.4	202	378.35	9.698	90.43	1	0.264647
27.3-28.3	209	391.45	9.698	90.43	1	0.255783
27.3-28.3	215	402.69	9.698	90.43	1	0.248645
28.3-29.3	210	393.32	9.698	90.43	1	0.254565
28.8-29.3	216	404.56	9.698	90.43	1	0.247494
28.3-30.3	220	412.05	9.698	90.43	1	0.242994
30.8-31.8	240	449.51	9.698	90.43	1	0.222745
31.7-32.7	238	445.77	9.698	90.43	1	0.224616
32.7-33.7	222	415.80	9.698	90.43	1	0.240805
33.7-34.7	223	417.67	9.698	90.43	1	0.239725
Average	219.08	410.34	Average		1	0.244949
Average					1 Joule=0.244949 Calorie	

4.3 Expert Examination

Expert examination was conducted to obtain validation of instrument used in this research. Expert examination was conducted toward student work sheet, student responses questionnaire, lesson plan and questions test. The results of expert validation are shown on Table 2.

Table 2: Results of Expert Examination

Instrument	Validator			Averages	Category
	1	2	3		
Student work sheet	72.5	91.25	87.5	83.75	Valid
Student responses questionnaire	93.75	96.87	94.25	94.96	Valid
Lesson plan	84.09	85.22	86.72	85.34	Valid
Questions test	3.625	3.5	3.625	3.58	Very Good

The validity, reliability, differentiation and difficulties of the questions test were obtained from analyzing the result of test given to 27 senior high school students who had learned the heat topic. The analysis gave 12 questions from 33 questions with valid category and then can be used in the field test.

4.3 Field Examination

Field test is conducted through implementation of heat learning media in learning process about heat and its effect to the change of the form of matters. The experimental one group pretest-posttest was used in this step. The students involved in this step are 24 senior high school students of grade X. Pretest was given to the students before the class started. After pretest, the class was treated with learning based on process using the heat learning media and its students' worksheets. Finally, the students were given posttest with the same questions as pretest and then filled out the response questionnaire.

Table 3: Results of t test paired sample (pretest and posttest)

No.	Item	Data	t	Criteria
1	Degree of freedom	23	$t_{count}>t_{table}$	There are enhancement on science process skills of students
2	Significance	0,05		
3	t_{count}	7,07		
4	t_{table}	2,07		

The results of pretest and posttest for each aspect of science process skill are shown on Figure 5. The data shows that after treatment with pre-experimental one group pretest-posttest both planning experiment and interpretation reach very good criteria, whereas observation and formulating hypothesis reach good criteria followed by communication with good enough criteria.

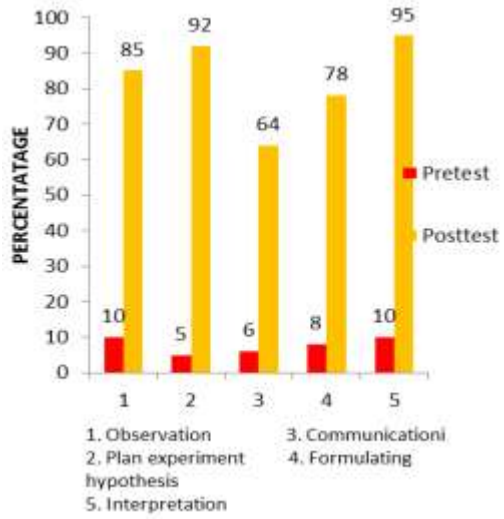

Figure 5: Science Process Skills of Students

The student responses questionnaire aims to know how the opinion of student toward the heat learning media, learning process with heat learning media and student worksheets. The results of student responses questionnaire analysis are shown on Table 4 below.

Table 4: Results of students' responses

No.	Aspects	Percentage (%)	Criteria
1	Students responses toward heat learning media	94	Very good
2	Students responses toward learning process using heat learning media	93	Very good
3	Student responses toward student work sheet	96	Very good

Final product of this research is heat learning media based on microcontroller ATMEGA8535 that can be used as learning media on the topic of heat. This learning media can help teachers to conduct better learning model than traditional model. It can also help students to observe, interpret, formulate hypothesis, communicate and plan experiment in heat topic. These conditions can be reached because students can do experiment directly, record data, analyze data and interpreted by the support of student worksheet. Beside these benefits, such abstract concepts which were taught traditionally, for example, about latent heat can be observed directly using heat learning media. This result is consistent with those of previous studies [22] [23] [24].

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Based on the results of pretest and posttest, it can be inferred that heat learning media is effective to enhance students' science process skills on heat topic. This is shown by the increasing scores of students pretest compared to posttest. Based on the results of students' responses questionnaire analysis, it is shown that most students agree that heat learning media help them to learn and understand heat topic in physics lesson. Therefore it can be inferred that the heat learning media is effective and feasible to be used in learning process to enhance students' science process skill.

The advantages of using heat learning media are: 1) The learning media is equipped with digital thermometer (LM35 sensor) and timer so students can easily observe and tabulate data; 2) The learning media is equipped with heater filament which is controlled automatically so students can directly observe the change of materials form only by pressing a button; 3) The learning media is equipped with student worksheet that can guide student to do an experiment; 4) The learning media can be used for several purposes such as to measure the temperature only or to measure the temperature, to count time and to set the heater on fire together ; 5) The learning media can be used for several experiment such as Black principle, Newton cooling constant, observe the change of materials form, measure the temperature only and prove the relation between Calorie and Joule.

As shown before, the implementation of learning media can enhance science process skill of students. All aspects of science process skills of students examined in this research increase according to pretest and posttest i.e., observation (75%), plan experiment (87%), communicate (58%), formulate hypothesis (70%) and interpreted (85%). It is shown that the enhancement is very significant because students are familiar with learning media in heat topic, so they can construct their comprehension about heat based on what they have seen directly. The effect of the learning media is also found through the analysis of student responses questionnaire. Most of students said that both learning media and learning using heat learning media is very good (94% and 93%) on helping students comprehension and science process skill about heat. This is similar with some of the research carried out by earlier researcher [6] [25] [26]. Therefore, it can be inferred that the heat learning media is effective to enhance the science process skills of students and feasible to use in learning process.

5. Conclusion

A heat learning media has been developed base on microcontroller ATMEGA8535 to enhance science process skill of students. This learning media has been tested and the results of the test shown that it is effective to enhance science process skills of students and feasible to use on learning process. This conclusion based on result of analyzing pretest and posttest using t test paired sample. Each aspect of science process skills which was examined in this research (observation, formulating hypothesis, planning experiment, interpretation, and communication) grew up after using heat learning media on learning process.

The heat learning media is feasible to use in learning process based on the result of analyzing students' responses. Most students said that both learning media and learning using heat learning media is very good on helping them understand the topic. The suggestion for the next development is using temperature sensor which has high sensitivity in order to get better result. Beside that the heat learning media have to be equipped with a material case that can prevent the heat flow from the box to the environment.

References

[1] Carin, A. (1997). *Teaching Modern Science.* New Jersey: Pretince-Hall, Inc.
[2] Asbanu, D. E., & Babys, U. (2017). The Development of Sound Wave Audacity Base Learning Media Using Ethnoscience Approach of Amanuban Tribe to Improve Physics Teacher Candidates' Science Process Skil. *lInternational Journal of Science and Research (IJSR)*, 324-329.
[3] FARSAKOĞLU, Ö. F., ŞAHİN, Ç., & KARSLI, F. (2012). Comparing science process skills of prospective science teachers: A cross-sectional study. *Asia-Pacific Forum on Science Learning and Teaching*, -.
[4] YILDIRIM , M., ÇALIK, M., & ÖZMEN, H. (2016). A Meta-Synthesis of Turkish Studies in Science Process Skills. *INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION*, 6518-6539.
[5] Gultepe, N. (2016). High School Science Teachers' Views on Science Process Skills. *International Journal of Environmental & Science Education*, 11(5), 779-800.
[6] Siahaan, P., Suryani, A., Kaniawati, I., & Samsudin, A. (2017). Improving Students' Science Process Skills through Simple Computer Simulations on Linear Motion Conceptions. *Journal of Physics: Conference Series, 812*.
[7] Duruk, U., Akgün, A., Doğan, C., & Gülsuyu, F. (2017). Examining the Learning Outcomes Included in the Turkish Science Curriculum in Terms of Science Process Skills: A Document Analysis with Standards-Based Assessment. *INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION, 12*(2), 117-142.
[8] Trimaryana, O. F., & Retinofa, R. R. (2016). The Application of Traditional Game Rorodaan as Learning Tool in Physics Subject: Force and Movement to Improve Learning Results. *Journal of Physics: Conference Series 739*, -.
[9] AYDOĞDU, B. (2015). Examining preservice science teachers' skills of formulating hypotheses and identifying variables. *Asia-Pacific Forum on Science Learning and Teaching, 16*(1), -.
[10] KEMENDIKBUD. (2013). *National Curriculum Year 2013.* Jakarta: Ministry of Education and Culture Republic of Indonesia.
[11] Manurung, S., & Pangabean, D. D. (2017). Analysis of Learning Tools in the Study of Developmental of Interactive Multimedia Based Physic Learning Charged in Problem Solving. *Journal of Physics: Conf. Series*.
[12] AYDIN, M., BAKIRCI , H., ARTUN , H., & ÇEPNİ, S. (2013). Effectiveness of technological design on

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elementary student teachers' understanding of air resistance, gravity, terminal velocity and acceleration: Model parachute race activity. *Asia-Pacific Forum on Science Learning and Teaching, 14*(1).
[13] Roth, W. (2001). Learning science through technological design. *Journal of Research in Science Teaching, 38*(7), 768-790.
[14] Pereira, N. (20016). Measuring the RC time constant with Arduino. *Physic Education, 51*, 1-10.
[15] Ratnasari, Sukarmin, S., Suparmi , S., & Aminah, N. (2017). Students' Conception on Heat and Temperature toward Science Process Skill . *Journal of Physics: Conf. Series 895 (2017) 012044*.
[16] Daryanto. 2011. *Media Pembelajaran.* Bandung: Gaung Persada (GP) Press Jakarta.
[17] Adrinato, H. (2013). *Pemrograman Mikrokontroler AVR ATMEGA16 Menggunakan Bahasa C (CodeVisionAVR.* Bandung: Informatika.
[18] Giancoli, D. (2001). *Fisika Jilid I.* Jakarta: Erlangga.
[19] Abdullah, M. (2016). *Fisika Dasar 1.* Bandung: Institut Teknologi Bandung.
[20] Arikunto, S. (2002). *Prosedur Penelitian Pendidikan.* Jakarta: Rineka Cipta.
[21] Sugiyono. (2012). *Metode Penelitian Kualitatif, Kuantitatif dan R&D.* Bandung: Alfabeta.
[22] Foulds, W., & Rowe, J. (1996). The enhancement of science process skills in primary teacher education students. *Australian Journal of Teacher Education, 21*(1), 16-23.
[23] Sidawi, M. (2009). Teaching science through designing technology. *International Journal of Technology & Design Education, 19*(3), 269-287.
[24] AKA, E. Ġ., GÜVEN, E., & AYDOĞDU, M. (2010). Effect of Problem Solving Method on Science Process Skills and Academic Achievement. *Journal of TURKISH SCIENCE EDUCATION, 7*(4), 13-25.
[25] Sartika, R. (2011). *Pengaruh Pendekatan Keterampilan Proses Sains Terhadap Keterampilan Proses Sains Siswa Pada Konsep Suhu dan kalor*. Jakarta: UINS.
[26] Mayasari, D. (2017). Bockron as a Medium of Learning in The Process of Inquiry based Learning to Improve Science Process Skills of Junior High School Students in Growth and Development Concept. *Journal of Physics: Conf. Series 812*.

Author Profile

Kostan D. F. Mataubenu received the S.Si. degrees in Nusa Cendana University and M.Si in Institut Technology Bandung in 2011 and 2014, respectively. During 2015-2018, he worked at physics department of Sekolah Tinggi Keguruan dan Ilmu Pendidikan Soe, Indonesia.

Demeryati Langtang received the S.Pd. degrees in Universitas Kristen Satya Wacana Salatiga and M.Pd. in Universitas Negeri Semarang in 2011 and 2015, respectively. During 2015-2018, he worked at physics department of Sekolah Tinggi Keguruan dan Ilmu Pendidikan Soe, Indonesia.

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