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EXPLORING MIDDLE SCHOOL STUDENT RESPONSE AND ATTITUDES TOWARD STEM ON HEAT AND TEMPERATURE TOPIC

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Abstract

This study explores the effect of STEM (Science, Technology, Engineering, and Mathematics) learning using the EDP (Engineering Design Process) model on the attitudes of seventh-grade junior high school students on heat and temperature. This research is quantitative. The method used in this study is a quasi-experimental study with a one-shot case study design. The sample is 31 students from class VII-11 Public Junior High School at Samarinda City. Data collection techniques using a questionnaire technique. The results of the data analysis of the value of R square, the coefficient of determination is 39,6%, and the significant value in the simple linear regression test is 0,000. These results indicate that STEM learning with the EDP model affects student attitudes, so applying STEM to shape students' attitudes towards STEM is essential.

Keywords: Science, Technology, Engineering, and Mathematics (STEM), Engineering Design Process (EDP) model, Student Response, Student Attitudes.

Introduction

The 21st century is information that is increasingly easy to obtain and the rapid development of technology (Muyassarah et al., 2019). In the development of technology and science, adjustments are needed in developing education that can take advantage of existing technological and scientific developments, one of which is by using the approach Science, Technology, Engineering, Mathematics (STEM) (Irmawati et al., 2021). Student involvement during STEM activities was very high, including STEM topic activities, design activities, and student relationships with classmates (Sulaeman et al., 2021). STEM is one of the most popular approaches because it has been mentioned recently, with innovation and design being crucial for every country (Hernandez et al., 2014; Gülhan & Şahin, 2016). Integrating the four disciplines can help students acquire knowledge and skills of collaboration, thinking, critical thinking, creativity, and problem-solving. It will impact students' argument ability (Hasanah et al., 2022).

The importance of activities in STEM, so from the beginning, students need to be directed to build a positive attitude towards STEM; even in the 2013 curriculum, during the learning process, students need to have good character (Suprapto, 2016; Sabillah, 2020). A good student attitude will support aspects of student knowledge and skills. The advancement of knowledge, skills, and perspectives in the STEM field is significant for national security, economic growth, citizens' health, and the nation's stability (Popa & Ciascai, 2017). With a good attitude, students will affect their choice of high school majors, major college choices, and future career choices (Ball et al., 2017). Therefore, student attitudes are seen as necessary in learning to be presented to students.

Several facts prove that students' attitudes towards science generally decline along with the progress of education, which has changed from time to time (Uğraş, 2018). Over the past few years, fewer and fewer students have been interested in scientific and technological issues (Osborne & Dillon, 2008). Research in the United States shows that with the start of losing competitiveness in the fields of science, technology, and engineering, because of this the United States has led a reform called STEM education to increase the number of students and the quality of education in these fields (Dugger, 2010; Kan & Murat, 2018). Other research is in developing countries such as Indonesia, which is included in the top seven countries with the most STEM graduates worldwide. Still, the fact that ratio or comparison with the population in Indonesia shows that it is not in the top seven anymore; there are only seven people who graduated from STEM out of the 10.000 population; this indicates that the current system must increase STEM graduates (OECD, 2014; Suwono et al., 2019). Thus, students' positive attitude towards STEM science is very important.

Handling and managing emotions during the learning process is closely related to attitudes and is essential in providing good student attitudes (Perdana et al., 2019). Students with a positive attitude in learning science are easier to understand because it positively impacts student learning outcomes (Hsu et al., 2019). A good attitude affects the application of STEM in daily teaching and learning (Wahono & Chang, 2019).

Design is part of the STEM world, which is knowledge built from various student characteristics. STEM has one of the characteristics of the learning process, namely the Engineering Design Process (EDP) (Ulum et al., 2021). Learning and teaching science-based on EDP is a learning model that can train students better in the thinking process (Syukri et al., 2018). Regarding the use of EDP in the STEM learning process in Junior High School, previous research has been carried out and resulted that EDP can develop students in providing solutions and solving a problem, where this is the result of the students' thinking process abilities. (Utomo et al., 2021). The STEM learning given is heat and temperature material. In this material, students can be taught science and engineering practices (Triwulandari et al., 2021).

In STEM learning, it is carried out to increase students' interest in science by integrating STEM into the learning process, which is the main thing in the global education system to ensure the achievement of learning outcomes for students who excel in the future (Xu & Lastrapes, 2021). The growth of a positive attitude toward STEM, it can increase student interest in science and professions related to STEM (Razali et al., 2020). However, in Indonesia, research on the effect of STEM learning on students' attitudes about STEM is rarely done. Therefore, this study aims to analyze whether or not there is an effect of STEM learning on students' attitudes about STEM.

Research Method

This quantitative research uses STEM learning with the EDP model on the heat and temperature material for four meetings. The method used in this study is Quasi-Experimental research and One-Shot Case Study Design. The sample used in this study were seventh-grade public Junior High School students in Samarinda city, totaling 31 students (male = 15, female = 16). The data collection technique used a closed questionnaire distributed after being given treatment to students. The attitude questionnaire used was adapted from Unfried et al. (2015), and the STEM Learning questionnaire was adopted from (Astuti Mahayu Ariyawati et al. (2017), where the statement items of the attitude questionnaire and STEM learning use a Likert scale with an attitude questionnaire consisting of 24 statement items. The data analysis technique used in the research is quantitative using statistics (Sugiyono, 2013). Statistical test by performing a scoring system, normality test, and simple linear regression test. These response options used a 5-level Likert scale: strongly agree, agree, neutral, disagree, and strongly disagree.

Furthermore, the normality test aims to determine whether the data obtained in the study are normally distributed or not. The data is said to be normal if the significant value is greater than 0.05, and if the significant value is less than 0.05, the data is said to be abnormal. The simple regression test aims to determine the relationship between each variable, namely STEM learning (Variable X), with student attitudes (Variable Y). If significant (2-tailed) < α, so H_0 is rejected and H_1 accepted, and if significant (2-tailed) < α, then H_0 is accepted and H_1 is rejected.

Result and Discussion

The results of student attitude data and student response data on STEM learning are students' ability scores after implementing STEM learning with the EDP model in the classroom. The data will be analyzed to answer the problem formulation.

First, the attitude questionnaire data were obtained based on the score on the statement totaling 24 items given to 31 students in grades VII-11. Questionnaire statements were given to students at the last meeting after the STEM learning activities with the EDP model were completed. The following is a figure of the combined results of each statement code.

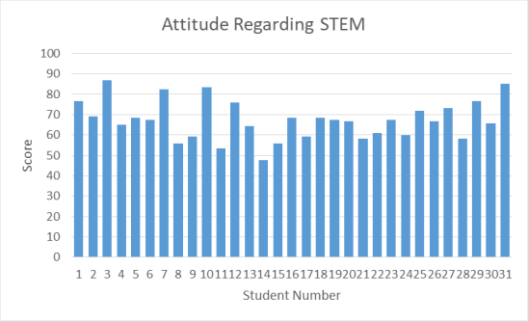

Figure 1. Student Attitude Score

The results of the attitude data with the lowest score obtained by student number 14 with a score of 48, and the highest score was student number 3 with a score of 87.

Second, the questionnaire data on student responses to STEM learning was obtained based on scores on statements totaling 12 items given to 31 students. Questionnaire statements were given to students at the last meeting after the STEM learning treatment with the EDP model was

completed. The following are the results of student statement scores on STEM learning.

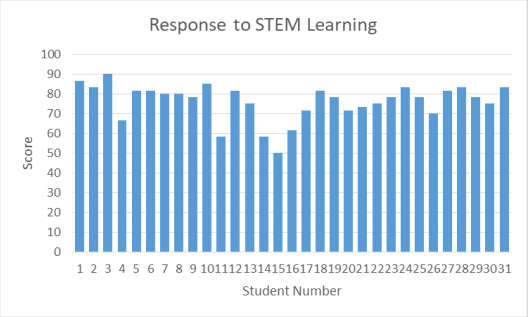

Figure 2. Student Response Score on STEM Learning

Based on Figure 2, it can be seen that the student data scores after being given treatment for STEM learning using the EDP model with the highest score obtained by student number 3 with a score of 90 and the lowest score of student number 15 with a score of 50.

Furthermore, before testing the hypothesis, a normality test is first performed on the research data as a prerequisite for testing the hypothesis. The hypothesis test used is simple linear regression.

Table 1. Normality Test Results

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		31
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	8.93994405
Most Extreme Differences	Absolute	.083
	Positive	.083
	Negative	-.078
Test Statistic		.083
Asymp. Sig. (2-tailed)		.200[c,d]

Based on Table 1, it can be interpreted that the significance value of (2-tailed) shows a value of 0,200 by the conditions for a normal distribution > 0,05. So, based on the normality test, the students' attitude data obtained were normally distributed.

Furthermore, the coefficient of determination (R^2) is carried out to see if there is a perfect relationship, which is indicated by changes in the independent and dependent variables.

Table 2. Coefficient of Determination

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.629[a]	.396	.375	7.598

a. Predictors: (Constant), STEM Learning

Based on Table 2 explaining the magnitude of the correlation value, it can be seen that the R-value is 0,629; this indicates a relationship between the x variable and the y variable. From the output, the coefficient of determination is obtained (R Square) of 0,396, which implies that the effect of the independent variable (STEM learning) on the dependent variable (student attitudes) is 39.6%

Furthermore, measuring student attitudes and student responses to STEM learning

Table 3. Simple Linear Regression Results

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1(Constant)	16.895	11.639		1.452	.157
STEM Learning	.662	.152	.629	4.363	.000

a. Dependent Variable: Attitude

Based on the results of a simple regression test, it is known that the value of constant (a) is 16.895. In contrast, the value of STEM learning (b/ regression coefficient) of 0.662 so that the decision making in the Simple Regression Test is known that the significance value of (2-tailed) the result shows the value that ≤ 0,05 that is 0,000. It can be concluded that the STEM Learning variable with the EDP model (X) affects the Student Attitude variable (Y). This effect can be seen from the hypothesis test carried out using the regression test in Table 3, H_0 is rejected, and H_1 is accepted because the significance value (2-tailed) obtained is 0,000.

This study's STEM learning with the EDP model went quite well according to the Learning Implementation Plan (RPP). The implementation of STEM learning with the EDP model goes through several stages. The first stage is the "define and learn" stage. At this stage, students collect information to determine existing problems, ask questions and discuss them with their friends. Through this activity, students become aware of what issues must be solved later. In the "plan" stage, students and their groupmates discuss finding a solution to the problem by designing a vaccine storage area. Each group tested their answers in the "test" stage to see if the vaccine site met the criteria. In the "decide" stage, each group presents the results of their project in front of the class.

The data on student number 14 got the lowest score on attitude data regarding STEM with a score of 48 because students get a lower score on the Mathematics code than on the Science code and Engineering & Technology code. Thus, students' low interest in learning mathematics is caused by the perceived difficulties of these subjects. In addition, further research suggests that the main reason for the low interest of students in learning mathematics is that the principles are complex and time-consuming to understand (Bingolbali et al., 2007).

Based on the results of students on STEM learning with the EDP model, it can be seen that students are happy and become active in learning activities in class. The STEM approach enables students to understand learning material and solve problems, especially heat and temperature material; students also become more optimistic and motivated when learning occurs. This is in line with previous research, which states that STEM learning can increase student motivation in learning so that students become more creative and have better attitude dimensions (Fitriansyah et al., 2021). STEM learning in the EDP model can improve student attitudes about STEM. Research from Tseng et al. (2013) states that most students are aware of the importance of STEM in the field of study, among others, useful for their future careers, improving life and society, and making the world a more comfortable and efficient place. The other research that is relevant to the results in this study is the research of Suprapto (2016), which shows a significant relationship between the dimensions of attitude towards STEM; this is an important factor that influences students' motivation to study STEM learning and can pursue a career in the STEM field. Another research from Ibrahim & Şeker (2022) showed that students' attitudes towards STEM learning were needed to support the full implementation of the STEM approach in schools. Therefore, STEM learning needs to be explored as much as possible to influence students' attitudes in pursuing future careers.

Conclusion

Based on the results and discussion, it was concluded that STEM learning with the EDP model affected students' attitudes about STEM with proven results from the coefficient of determination (R Square) of 0,396, which implies the effect of STEM learning on student attitudes is 39,6%. A simple regression test also shows that the resulting (2-tailed) significance value shows a value less than 0,05, which is 0,000. Therefore, it can be concluded that STEM learning with the EDP model affects student attitudes. With the application of STEM learning, the EDP model is expected to be a reference for schools to apply STEM learning to other materials to maximize student learning activities. The implementation of STEM with the EDP Model is also expected to be an inspiration for further research so that it can be developed and pay more attention to student attitudes during learning.

Reference

Astuti Mahayu Ariyawati, P., Waluyo, J., & Prihatin, J. (2017). Analisis Respon Siswa terhadap Model Pairs, Inbertigation and Communication (PIC) dalam pembelajaran IPA. *Jurnal Pembelajaran Dan Pendidikan Sains*, *2*(1), 9–15.

Ball, C., Huang, K. T., Cotten, S. R., & Rikard, R. V. (2017). Pressurizing the

STEM Pipeline: an Expectancy-Value Theory Analysis of Youths' STEM Attitudes. *Journal of Science Education and Technology*, *26*(4), 372–382. https://doi.org/10.1007/s10956-017-9685-1

Bingolbali, E., Monaghan, J., & Roper, T. (2007). Engineering students' conceptions of the derivative and some implications for their mathematical education. *International Journal of Mathematical Education in Science and Technology*, *38*(6), 763–777. https://doi.org/10.1080/00207390701453579

Dugger, W. E. (2010). Evolution of STEM in the United States. *6Th Biennial International Conference on Technology Education Research*, *March*, 1–8. http://www.iteea.org/Resources/PressRoom/AustraliaPaper.pdf

Fitriansyah, R., Werdhiana, I. K., & Saehana, S. (2021). Pengaruh Pendekatan STEM dalam Model Inkuiri Terbimbing Terhadap Sikap Ilmiah dan Kerja Ilmiah Materi IPA. *Jurnal Ilmiah Pendidikan Fisika*, *5*(2), 225. https://doi.org/10.20527/jipf.v5i2.3598

Gülhan, F., & Şahin, F. (2016). The effects of science-technology-engineering-math (STEM) integration on 5th grade students' perceptions and attitudes towards these areas<p>Fen-teknoloji-mühendislik-matematik entegrasyonunun (STEM) 5. sınıf öğrencilerinin bu alanlarla ilgili algı ve tut. *International Journal of Human Sciences*, *13*(1), 602. https://doi.org/10.14687/ijhs.v13i1.3447

Hasanah, F., Dwi, P., & Putra, A. (2022). Identifikasi Kemampuan Siswa SMP dalam Berargumentasi Melalui Pendekatan Pembelajaran Science , Technology , Engineering , and Mathematics (STEM). *Jurnal Literasi Pendidikan Fisika*, *3*(1), 1–9.

Hernandez, P. R., Bodin, R., Elliott, J. W., Ibrahim, B., Rambo-Hernandez, K. E., Chen, T. W., & De Miranda, M. A. (2014). Connecting the STEM dots: Measuring the effect of an integrated engineering design intervention. *International Journal of Technology and Design Education*, *24*(1), 107–120. https://doi.org/10.1007/s10798-013-9241-0

Hsu, P. S., Lee, E. M., Ginting, S., Smith, T. J., & Kraft, C. (2019). A Case Study Exploring Non-dominant Youths' Attitudes Toward Science Through Making and Scientific Argumentation. *International Journal of Science and Mathematics Education*, *17*, 185–207. https://doi.org/10.1007/s10763-019-09997-w

Ibrahim, M., & Şeker, H. (2022). Examination of the attitudes of grade 7 and 8 students towards STEM education in Turkey and Ghana. *LUMAT: International Journal on Math, Science and Technology Education*, *10*(1). https://doi.org/10.31129/lumat.10.1.1657

Irmawati, I., Syahmani, S., & Yulinda, R. (2021). Pengembangan Modul IPA Pada Materi Sistem Organ Dan Organisme Berbasis STEM-Inkuiri untuk Meningkatkan Literasi Sains. *Journal of Mathematics Science and Computer Education*, *1*(2), 64. https://doi.org/10.20527/jmscedu.v1i2.4048

Kan, A. Ü., & Murat, A. (2018). Investigation of Prospective Science Teachers' 21st Century Skill Competence Perceptions and Attitudes Toward STEM. *International Online Journal of Educational Sciences*, *10*(4), 251–272.

Muyassarah, A., Ratu, T., & Erfan, M. (2019). Pengaruh Pembelajaran Fisika Berbasis STEM Terhadap Kemampuan

Motorik Siswa. *Prosiding SNFA (Seminar Nasional Fisika Dan Aplikasinya)*, *4*, 1. https://doi.org/10.20961/prosidingsnfa.v4i0.35906

OECD, O. for E. C. and D. (2014). PISA 2012 Results: What Students Know and Can Do (Volume I, Revised edition, February 2014): Student Performance in Mathematics, Reading and Science. In *OECD Publishing*.

Osborne, J., & Dillon, J. (2008). Science education in Europe: Critical reflections. *London: Nuffield Foundation*, *January*, 8. http://www.fisica.unina.it/traces/attachments/article/149/Nuffield-Foundation-Osborne-Dillon-Science-Education-in-Europe.pdf%5Cnpapers2://publication/uuid/FA17ED57-71AF-429E-B7E5-D9E33DA4A538

Perdana, R., Subiyantoro, C., & Anggraini, L. (2019). Sikap dan Motivasi pada Mata Pelajaran Fisika. *SPEKTRA : Jurnal Kajian Pendidikan Sains*, *5*(2), 178. https://doi.org/10.32699/spektra.v5i2.102

Popa, R.-A., & Ciascai, L. (2017). Students' Attitude towards STEM Education. *Acta Didactica Napocensia*, *10*(4), 55–62. https://doi.org/10.24193/adn.10.4.6

Razali, F., Manaf, U. K. A., Talib, O., & Hassan, S. A. (2020). Motivation to learn science as a mediator between attitude towards STEM and the development of stem career aspiration among secondary school students. *Universal Journal of Educational Research*, *8*(1 A), 138–146. https://doi.org/10.13189/ujer.2020.081318

Sabillah, D. S. (2020). Pengembangan Instrumen Penilaian Sikap Pada Pembelajaran STEM dengan Media Perahu Bertenaga Uap di Kelas V Sekolah Dasar. *Fundamental Pendidikan Dasar*, *3*(2), 147.

Sugiyono. (2013). *Metode Penelitian Kuantitatif Kualitatif dan R&D*. Alfabeta.

Sulaeman, N. F., Putra, P. D. A., Mineta, I., Hakamada, H., Takahashi, M., Ide, Y., & Kumano, Y. (2021). Exploring Student Engagement in STEM Education through the Engineering Design Process. *Jurnal Penelitian Dan Pembelajaran IPA*, *7*(1), 1. https://doi.org/10.30870/jppi.v7i1.10455

Suprapto, N. (2016). Students' attitudes towards STEM education: Voices from Indonesian junior high schools. *Journal of Turkish Science Education*, *13*(Specialissue), 75–87. https://doi.org/10.12973/tused.10172a

Suwono, H., Fachrunnisa, R., Yuenyong, C., & Hapsari, L. (2019). Indonesian Students' Attitude and Interest in STEM: An Outlook on the Gender Stereotypes in the STEM Field. *Journal of Physics: Conference Series*, *1340*(1). https://doi.org/10.1088/1742-6596/1340/1/012079

Syukri, M., Soewarno, S., Halim, L., & Mohtar, L. E. (2018). The impact of engineering design process in teaching and learning to enhance students' science problem-solving skills. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 66–75. https://doi.org/10.15294/jpii.v7i1.12297

Triwulandari, S., Azizah, R. D. A. F. Z., Syam, M., Putra, P. D. A., & Sulaeman, N. F. (2021). Exploring Science and Engineering Practices in Indonesian Physics Textbook about Heat and Temperature. *ICTROPS International Conference for Tropical Studies and Its Applications*.

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment.

International Journal of Technology and Design Education, *23*(1), 87–102. https://doi.org/10.1007/s10798-011-9160-x

Uğraş, M. (2018). The Effects of STEM Activities on STEM Attitudes, Scientific Creativity and Motivation Beliefs of the Students and Their Views on STEM Education. *International Online Journal of Educational Sciences*, *10*(5). https://doi.org/10.15345/iojes.2018.05.012

Ulum, M. B., Putra, P. D. A., & Nuraini, L. (2021). Identifikasi penggunaan EDP (Engineering Design Process) dalam berpikir engineer siswa SMA melalui Lembar Kerja Siswa (LKS). *Jurnal Riset Dan Kajian Pendidikan Fisika*, *8*(2), 53. https://doi.org/10.12928/jrkpf.v8i2.20753

Unfried, A., Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The Development and Validation of a Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM). *Journal of Psychoeducational Assessment*, *33*(7), 622–639. https://doi.org/10.1177/0734282915571160

Utomo, A. P., Prismasari, D. I., & Narulita, E. (2021). The Effect of Agrosains Based Engineering Design Process Learning Model With A Stem Approach to SMP Student. *Jurnal Pendidikan Sains (Jps)*, *9*(2), 120. https://doi.org/10.26714/jps.9.2.2021.120-125

Wahono, B., & Chang, C. Y. (2019). Development and validation of a survey instrument (AKA) towards attitude, knowledge and application of stem. *Journal of Baltic Science Education*, *18*(1), 63–76. https://doi.org/10.33225/jbse/19.18.63

Xu, C., & Lastrapes, R. E. (2021). Impact of STEM Sense of Belonging on Career Interest: The Role of STEM Attitudes. *Journal of Career Development*, 1–15. https://doi.org/10.1177/08948453211033025