Students’ Conception on Heat and Temperature toward Science Process Skill

D Ratnasari*, S Sukarmin, S Suparmi and N S Aminah
Program Magister Pendidikan Sains, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Keningan, Surakarta 57126, Indonesia

* dewi_ratnasari@student.uns.ac.id

Abstract. This research is aimed to analyze the effect of students’ conception toward science process skill. This is a descriptive research with subjects of the research were 10th-grade students in Surakarta from high, medium and low categorized school. The sample selection uses purposive sampling technique based on physics score in national examination four latest years. Data in this research collecting from essay test, two-tier multiple choice test, and interview. Two-tier multiple choice test consists of 30 question that contains an indicator of science process skill. Based on the result of the research and analysis, it shows that students’ conception of heat and temperature affect science process skill of students. The students’ conception that still contains the wrong concept can emerge misconception. For the future research, it is suggested to improve students’ conceptual understanding and students’ science process skill with appropriate learning method and assessment instrument because heat and temperature is one of physics material that closely related with students’ daily life.

1. Introduction
Science process skill is considered as definitive and inseparable part of science education [1, 2]. The Scientific method, mindset and critical thinking are terms of this skill, in any case of the latest two decades, science process skill is more familiar [3, 4, 5]. Science process skills are skills commonly used by scientists to construct knowledge to solve and evaluate problems to obtain results [5, 6]. Science process skill is important not only to prepare scientists and technologists in the future but for the whole population who need science literacy to live and function in a world where science affects almost every aspect of personal, social and global life [7]. Science process skill is not handed skill using tools but it is a thinking skill by using a scientific method to facilitate students to understand a scientific concept. Science process skill is essential to the meaningful learning because it will continue to students' daily life. Students must also be able to find, interpret and look for evidence through different conditions [8].

Science process skill becomes focused attention by science educator for several decades [8]. Therefore, science process skill is very important in science teaching process to lead knowledge and become an important purpose in science education [9]. There are many former researchers who state the importance of science process skill in science learning process. Science process skill is a particular skill in minimizing science learning a process, activating students, developing students’ sensitivity in learning, and making the concept to be more permanent by using scientific method [10]. Learning with science process skill means learning with understanding in science that Involving possible
explanations to make predictions or to answer questions and interpret the results [11]. Students’ understanding and science process skill become inseparable part to improve students’ achievement.

Heat and temperature become an important subject that prevalent throughout all level in elementary, secondary and graduate education [12]. Heat and temperature undoubtedly one of the most difficult concepts of the secondary science curriculum. This is due to the definition of terms from the different heat of each literature, for example, heat is energy’, ‘heat is a form of energy’, ‘heat comes from the sun’, ‘heat is internal energy’, etc [13]. One of concept in physics whose concept understanding still low in heat and temperature. There are many students who still face difficulty in understanding heat and thermodynamics [14, 15, 16, 17]. One of the difficult concepts for students is differentiating between heat and temperature [18, 15]. One of the main topics in science education is concept understanding and students’ misconception of heat and temperature. The main reason is that heat and temperature are familiar words in daily life [13]. Students still face misconception of heat and temperature because students' knowledge on the concept of heat and temperature relates directly to daily life. Therefore, heat and temperature can’t be observed directly [19]. Students come from various impression and conception in their daily life that may be wrong [20]. Students’ conception of science topics can affect students’ achievement and students’ thinking skill such as students’ science process skill. This study focused on the effect of students' conception of heat and temperature toward students’ science process skill. The results of this study can be used for future research to determine the appropriate learning method for improving students’ science process skill and students’ conceptual understanding.

2. Experimental Method
This research is a descriptive research that is aimed to figure out a profile of students' science process skill. Research subjects were 10th-grade students in the academic year of 2016/2017. There are 148 students from high, medium, and low categorized school in Surakarta. The category is based on the score of national examination at the latest four years. Data collection tools for this research using essay test and interview for students’ conception data. Data of students’ science process skill is obtained from students’ test using assessment instrument of two-tier multiple choice. Data that consists of a result of students' test is used to analyze the achievement of each indicator of science process skill. The indicators are formulating a hypothesis, designing experiment, analyzing data, applying the concept, communicating and making a conclusion. An instrument of two-tier multiple choice consists of 2 objective tests, the first part is the main question (first-tier), and the second part (second tier) is the reasons of answer choice. Being supported by a scoring model of Graded Response Model (GRM), teachers will be easier in correcting students’ answer and detecting students’ skill [21]. The assessment guidance with a scoring model of GRM can be seen in Table 1.

| No | Assessment aspect                                      | Score |
|----|--------------------------------------------------------|-------|
| 1  | Do not choose any answer and reason, or wrong answer-wrong reason | 0     |
| 2  | Wrong answer-correct reason                            | 1     |
| 3  | Correct answer-wrong reason                            | 2     |
| 4  | Correct answer-correct reason                          | 3     |

3. Result and Discussion

3.1 Preliminary study
A preliminary study of this research aimed to an analysis of students' conception in heat and temperature. On this step use essay test that consists of 10 question about the basic concept of heat and temperature. Data of students’ conception also strengthened with an interview. The interview is used to confirm and to explore students’ conception. The result and data analysis of students’ conception can be seen in Table 2.
Table 2. Students’ conception on heat and temperature

| Concept                | Students’ conception                                                                 |
|------------------------|-------------------------------------------------------------------------------------|
| Temperature and expansion | 1. Temperature is only about hot and cold                                           |
|                        | 2. Skin can measure temperature                                                     |
|                        | 3. Objects with big masses have a big temperature                                    |
|                        | 4. The bigger expansion coefficient, the faster length increase.                    |
|                        | 5. The expansion coefficient of the thermometer filler does not affect the usefulness of the thermometer |
| Heat                   | 1. Heat and temperature is same                                                     |
|                        | 2. Heat not an energy                                                               |
|                        | 3. Objects with big masses have a big heat                                          |
|                        | 4. Objects divided into conductor and insulator with a perception that insulator considered to have no thermal conductivity value. |
|                        | 5. Objects cold fastly because specific heat                                        |
| Black principle        | 1. Black principle can’t determine specific heat of objects                          |
|                        | 2. Objects with big mass will release heat                                          |
|                        | 3. The container of substance does not receive or release heat                      |
| Heat transfer          | 1. Objects touch colder because specific heat                                       |
|                        | 2. Objects with bigger radius absorb the bigger heat                                 |

Table 3 shows an overview students’ conception on heat and temperature based on essay test and interview. Students’ conception on heat and temperature gained from daily life or previous concept from previous education level. The student's conception can be either the correct concept or the wrong concept. The wrong students’ conception can emerge misconception.

The research about students’ conception often termed alternative conception indicated that alternative conceptions are not same with the accepted scientific concept [23]. The results of the research can be used as input for teachers in order to develop a reliable and valid conception test instrument and using learning methods that are able to develop the concept of students.

Research on students’ conceptions has grown in the last twenty years. Preconception, misconceptions or alternative conceptions that students bring to class are now well accepted that alternative conceptions or common misconceptions occur in students and may disrupt students' understanding of subsequent concepts [24]. Students’ conception on heat and temperature become a focus of many researchers. On basic concept, students still confuse to distinguish clearly about heat and temperature concept [25, 26]. Most of the students can answer the question but unable to explain the underlying concept.

Students’ conception on heat and temperature caused by some factors such as students’ experience, students’ interpretation idea, culture and language [27, 28]. Another factor that caused students’ conception is textbooks may contribute and/or strengthen students’ alternative conceptions in heat and temperature [29].

3.2 An analysis of students’ science process skill
The instrument of two-tier multiple choice consists of 30 questions that contain indicators of science process skill. Each indicator consists of 5 questions. The instrument has been adapted from the indicators in syllabus used by teachers. The instrument of two-tier multiple choice is tested and analyzed its feasibility. If it is proper, the instrument is tested to 148 students from high, medium and low categorized school in Surakarta. The result of test analysis can be seen in Table 3.
Table 3. The indicator achievement of students’ science process skill.

| School category | Science Process Skill (SPS) Indicator | Achievement of science process skill (%) |
|-----------------|---------------------------------------|-----------------------------------------|
| High            | Formulating hypothesis                | 74.55                                   |
|                 | Designing experiment                  | 74.89                                   |
|                 | Analysing data                        | 67.89                                   |
|                 | Applying concept                      | 52.89                                   |
|                 | Communicating                         | 80.22                                   |
|                 | Making conclusion                     | 76                                      |
| Medium          | Formulating hypothesis                | 53.47                                   |
|                 | Designing experiment                  | 59.86                                   |
|                 | Analysing data                        | 42.22                                   |
|                 | Applying concept                      | 33.19                                   |
|                 | Communicating                         | 76.25                                   |
|                 | Making conclusion                     | 61.53                                   |
| Low             | Formulating hypothesis                | 51                                      |
|                 | Designing experiment                  | 55.17                                   |
|                 | Analyzing data                        | 39.17                                   |
|                 | Applying concept                      | 35.85                                   |
|                 | Communicating                         | 58.83                                   |
|                 | Making conclusion                     | 58                                      |

Table 3 shows that the average percentage of indicator achievement of science process skill on high, medium and low categorized school. Based on data of Table 3, it can be seen that the average achievement is various on each school. The highest achievement is at high categorized school. The difference among three schools is not quite significant. On indicator of applying the concept, the achievement percentage at low categorized school is higher than at medium categorized school.

The lowest percentage indicator is on applying the concept. This indicator is related to students' conceptual understanding. Concept understanding and physics learning process are related to each other. A good physics learning process must develop concept changing, both in widening and developing the concept. The wrong concept will be corrected so that it can apply that concept to solve problems. Therefore, concept understanding is an essential part to determine the achievement of physics learning purpose [30].

Conceptual understanding is defined as a skill to determine which relevant, accurate, and important idea to a problem and to understand the relation among microscopic attitude, macroscopic observation and chemical symbol and notation used to represent both [31, 32, 33, 34].

Another indicator that has low achievement is the skill of analyzing data. This indicator is related to students' skill in doing lab work and applying concept on their own. Data of students’ analysis is from lab work activity. It has been adapted from the concept they have learned. The low skill in analyzing data shows that students have not been able to conduct lab activity well. Science process skill is developed based on laboratory activity. Through laboratory activity, students gain meaningful learning, use science process skill, and understand the process on how they construct information in physics learning process.

The low percentage of an indicator is caused by competence test assessment that only focuses on concepts. In addition, teachers have not understood how to develop an instrument that can be used to measure science process skill. One of the solutions is by giving training to the science teachers about science process skill. The training consists of information about science process skill and its indicators and assessments. Through the training, it is expected that teachers can apply their knowledge in developing science process skill to the students [35].

Science process skill has also the positive impact on students' achievement. The former researches show that there is a positive correlation between academic achievement and science process skill [36,
37, 38]. Academic achievement and science process skill are related to the process of students' conceptual change. Therefore, it needs science process skill to develop high-level conceptual change. Science process skill can be separated from conceptual change and conceptual understanding [8]. Science process skill can be seen as a factor that supports concept understanding because it relates to academic achievement.

4. Conclusion

Based on the result of the research and analysis, it shows that students' conception of heat and temperature affect science process skill of students. The students' conception that still contains the wrong concept can emerge misconception. For the future research, it is suggested to improve students’ conceptual understanding and students’ science process skill with appropriate learning method and assessment instrument because heat and temperature is one of physics material that closely related with students’ daily life.

Acknowledgements

The writer would like to say her gratitude to her parents for their continuous prayers. For Mr. Sukarmin S.Pd, M.Si, Ph.D. and Mrs. Prof. Dra. Suparmi, M.A., Ph.D. and Mrs. Dr. Nonoh Siti Aminah, M.Pd who have guided in completing this article, the research group of post-graduate 2017 PNPB UNS and for all who have given their help to finish this article.

References

[1] Farsakoglu, O. F., Sahin, C., & Karsh, F. 2012 APFSLT 13 1-7
[2] Akgun, A., & Duruk, U. 2016 SEI 27 3-15
[3] Padilla, M.J. 1990. The Science Process Skills. (National Association of Research in Science Teaching Publication: Research Matters - to the Science Teacher).
[4] Bybee, R. W., & DeBoer, C. E. 1993. Research on goals for the science curriculum. In D. Gabel (Ed.), Handbook of research on science teaching and learning (New York: National Science Teachers Association) p. 357-387.
[5] Özgelen, S. 2012. Eurasia J. Math. Sci. and Tech. Ed., 8 283-292.
[6] Oslund, K. L 1992 Science process skill: Assessing hands-on student performance. (New York: Addison-Wesley)
[7] Harlen, W. 1999. Assess. Educ. Princ. Pol. Pract., 6 129-141.
[8] Karamustafaoglu, S. 2011. Eurasian J. Phys. Chem., 3 26-38.
[9] Shahali, E. H. M., & Halim, L. 2010 Procedia Soc. Behav. Sci., 9 142-146.
[10] Carey, S., Evans, R., Honda, M., Jay E., & Unger, C. 1989. Int. J. Sci. Educ., 11 514-529.
[11] Harlen, W. 2010 Assess. Educ. Princ. Pol. Pract., 6 129-144.
[12] Gonen S, and Kocakaya S 2010 EURASIA J. Phys. Chem. Educ. 2 1-15
[13] Sözbilir, M. 2003 BUJED 20 25-41.
[14] Driver, R 1989 Int. J. Sci. Educ. 11 481-490.
[15] Linn, M. and N. B. Songer 1991 J. Res. Sci. Tech. 28 885-915.
[16] Lewis, E. and M. Linn 1994 J. Res. Sci. Tech. 31 657-677.
[17] Harrison, A. G., D. J. Grayson, and D. F. Treagust 1999 J. Res. Sci. Tech. 36 55-87.
[18] Erickson, G. L 1979 Sci. Educ. 63 221–230.
[19] Arnold, M., and R. Millar 1994 Int. J. Sci. Educ.16 131-144.
[20] Kartal, T., Ozturk, N., & Yalvac, H.G 2011 Procedia Soc. Behav. Sci. 15 2758–2763.
[21] Wardani, R.K., Yamtinah, S., Mulyani, B. 2015. JPK, 4 156-162.
[22] Yamtinah, S., Haryono, Saputro, S., Mulyani, B., Suryadi, BU. 2016. Proceeding ICERE, 360-365.
[23] Antwi, V., & Areyetey, C. 2015 IJIRD 4 288-301
[24] Fisher, K. M., & Wandersee, J. H. 2001 Mapping Biology Knowledge (Dordrecht: Kluwer Academic Publisher).
[25] Carlton, K. 2000 Phys. Educ., 35 101-105.
[26] Yeo, S., & Zadnik, M. 2001 Phys. Teach., 39 495-504.
[27] Leura, G. R., Otto, C. A. & Zitzewitz, P. W 2005 Phys. Teach. 2 3-4.
[28] Lubben, F., Netshisuaalu, T., & Campel, B 1999 Sci. Educ. 83, 761-774.
[29] Leite, L. 1999 EJTE, 22 75-88.
[30] Suparno, P. 2013. Metodologi Pembelajaran Fisika (Konstruktivisme dan Menyenangkan) (Yogyakarta: Universitas Sanata Dharma).
[31] Nakhleh, M.B. 1993. J. Chem. Educ., 70 52-55.
[32] Nurrenbern, S. C. & Pickering, M. 1987. J. Chem. Educ., 64 508 - 510.
[33] Pickering, M. 1990. J. Chem. Educ., 67 254-255.
[34] Johnstone, A.H. 2006. Chem. Educ. Res. Pract., 7 49-63.
[35] Sukarno, Permanasi, A., & Hamidah, I. 2013. IJSER, 1 79-83.
[36] Beaumont-Walters, Y., & Soyibo, K. 2001. Res. Sci. Technol. Educ., 19 133-145.
[37] Sinan, O., & Usak, M. 2011. JSS, 8 15 333-348.
[38] Delen, I., & Kesercioglu, T. 2012. TUSED, 9 4 3-9.