Eleventh grade students’ conception analysis: a case-study on heat transfer

E N Syamsiah*, J Maknun, A Syamsudin, M Muslim, L Hasanah and A Suhandi
Departemen Pendidikan Fisika, Program Magister, Universitas Pendidikan Indonesia, Indonesia

*Corresponding author’s email: endahnursyamsiah@upi.edu

Abstract. We have precisely conducted research to identify students’ conceptions on heat transfer. A case study has been implemented by using purposive sampling technique. The research participants are 11 males and 24 females of eleventh grade students. The largest percentage of students’ conception is in the category of misconception, such as: (1) heat transfer is taking place while system has reached thermal equilibrium, so temperature difference still exists; (2) Objects that absorb heat more quickly, will emit heat radiation more slowly; (3) In conduction, heat flows because it is carried by moving electron of a medium; (4) In convection, the rate of convection goes faster as the water boils.

1. Introduction
Students conceptions has showed that students conceive the learning content in qualitatively different ways [1,2]. There has been a consistent and persistent message that these conceptions can be categorized in such a way as to reflect two predominant positions: (1) some students have a surface understanding of learning that involves the acquisition, storing, reproduction, and using of knowledge; (2) some students have a deep understanding of learning that involves the construction of meaning (understanding) and personal change [1].

Deep understanding of concepts related to physics will not be implemented if students begin learning with misinformation. This misinformation can keep students from the real scientific situation and result in misconceptions regarding certain content [3]. Students’ misconceptions are difficult to change in a short time because misconception is embedded in students’ thinking [4,5]. The assimilation process is done by comparing concepts with their old knowledge, adding more information to rearrange their knowledge [6]. But occasionally their previous knowledge is imperfect and inaccurate, resulting in a recurrence of repeated misconceptions [6-8].

Therefore, it is important for us to know students’ conceptions before and after learning, to ensure there are no misconceptions in students' understanding. Ways to identify students' conceptions by giving them multi-level questions. The multilevel type of question used is often a two-tier level problem or using CRI. However, the two types of multilevel questions are not able to categorize clearly the conception of students [9,10]. Types of questions that are often used now to categorize students' conceptions namely the three-tier test [11-13].

During the past few years, much effort has been put on studies of student’s misconceptions in various physical subject matters [14]. All that because many physics content contain abstract concepts that can trigger student misconceptions [15]. One concept that has the possibility of indicated misconceptions is heat transfer content [16]. The heat transfer itself consists of several basic content, namely: (1) thermal
equilibrium; (2) radiation heat transfer; (3) heat transfer by convection; and (4) heat transfer by conduction.

2. Methods

2.1. Participant
Participants in this research were 35 of K-11 students, consisting of 24 girls and 11 boys, whose age was around 16-17 years old. The students mostly have a middle to lower economic background.

2.2. Instrument
The instrument used in this research is diagnostic Three Tier Test which had previously been designed and tested by Suherli in his thesis. The questions' distribution for student conception analysis on heat transfer context is shown in Table 1 [17].

Table 1. The questions’ distribution for three tier tests

| No | Concept           | Misconception Indicator                                                                 | Question Number | Number of Question |
|----|-------------------|-----------------------------------------------------------------------------------------|-----------------|--------------------|
| 1  | Thermal equilibrium | heat transfer is taking place while system has reached thermal equilibrium, so temperature difference still exists | 1 – 3           | 3                  |
| 2  | Radiation         | Objects that absorb heat more quickly, will emit heat radiation more slowly             | 4 – 6           | 3                  |
| 3  | Conduction        | In conduction, heat flows because it is carried by moving electron of a medium          | 7 – 9           | 3                  |
| 4  | Convection        | In convection, the rate of convection goes faster as the water boils                   | 10 – 11         | 2                  |
|    |                   | Total                                                                                   |                 | 11                 |

The example of the three-tier test used is:

Two objects are inserted into the microwave with a temperature setting of up to 300°C. Two minutes later, it turns out that the object temperature A is higher than object B. If the two objects are removed from the microwave when we have the same temperature, then after a five-minute second temperature the object is… .

A. The temperature of object A will be higher than object B
B. The temperature of object B will be higher than that of object A
C. The temperature of object A will be the same as object B
D. The temperature of the two objects cannot be detected
E. The temperature of both is fixed

The most appropriate reason for your answer to that question is …

A. In radiation events, objects that absorb heat faster will be more slowly emitting heat.
B. In radiation events, objects that absorb heat faster will also emit heat
C. In radiation events, even though the absorption of each object is different, the transmission power will always be the same
D. In radiation events there are no objects that emit or absorb heat
E. All answers are correct

Are you sure of your answer?
A. Sure
B. Not sure

The open interview guide in this study is a supporting instrument of research carried out to students and teachers of physics subjects. The interview instrument submitted to the teacher consists of 5
questions and the interview instrument submitted to students consists of 4 main questions. These questions were not specifically designed before, all of which were the initiative of researchers during the field study. So, the questions asked have not been validated. The following are the questions asked by the researcher:

Point questions asked to related teachers:
2.2.1. How do teachers teach
2.2.2. What media are used during learning?
2.2.3. How do students respond to physics learning?
2.2.4. What are the learning outcomes of students?
2.2.5. What is the cause of the low learning outcomes of students?

Point questions asked to students
2.2.2.1. How do teachers teach?
2.2.2.2. What is the learning media often used by teachers?
2.2.2.3. What are the perceptions of students regarding physics learning?
2.2.2.4. What are their hopes for learning physics?

2.3. Technique of Analyses Data
Data regarding the state of conception obtained by the researchers was first processed by classifying students' answers to the criteria of Scientific Conception, Lack of Conception and Misconception. Categorization based on theoretical references which outlines in Table 2. [5]

| Tier 1 | Answer | Tier 2 | Answer | Tier 3 | Answer | Category |
|-------|--------|-------|--------|-------|--------|----------|
| Correct | Correct | Sure | Correct | Scientific Conception |
| Wrong | Correct | Sure | Error |
| Correct | Wrong | Sure | Misconception |
| Wrong | Correct | Sure | Misconception |
| Correct | Wrong | Not sure | Lack of Conception |
| Wrong | Wrong | Sure | Misconception |
| Wrong | Correct | Not sure | Lack of Conception |
| Wrong | Wrong | Wrong | Lack of Conception |

3. Results and Discussion

3.1. Misconception Analysis
Experimental data obtained were then classified based on the categories, then the calculation is done to find the percentage of students' conceptual categories of each item. But, it feels insufficient if we look at the state of the students' conception through the items of question, an overall average withdrawal is made based on the content group, as can be seen in the Figure 1:
Each student's conception categories show that misconceptions occupy the highest percentage, especially in convection content which reaches 79%. Misconceptions found namely: (1) heat transfer is taking place while system has reached thermal equilibrium, so temperature difference still exists; (2) Objects that absorb heat more quickly, will emit heat radiation more slowly; (3) In conduction, heat flows because it is carried by moving electron of a medium; (4) In convection, the rate of convection goes faster as the water boils.

3.2. Questionnaire results
The results of the questionnaire given to the teacher

**Table 3.** Teacher Questionnaire Results.

| No. | Question about                        | Answer                                    |
|-----|---------------------------------------|-------------------------------------------|
| 1   | The way the teacher teaches           | Prioritizing fun learning                 |
|     |                                        | Begin learning contextually               |
|     |                                        | Linking concepts to religion              |
|     |                                        | Hold a practicum (demonstration)          |
| 2   | Media used                            | Power point to display (content, simulation, video) |
|     |                                        | Simple props                              |
|     |                                        | Practical tools                           |
Table 4. The results of the questionnaire given to students.

| No. | Question about          | Answer                                                                 |
|-----|-------------------------|------------------------------------------------------------------------|
| 3   | Students response       | - The students’ response to physics learning is quite good             |
| 4   | Students Learning Outcomes | - Learning outcomes of students are still lacking                       |
| 5   | Deep obstacles Learning | - Physics time clock limitations                                  |
|     |                          | - Limitations of practicum tools and props                          |
|     |                          | - Input of students who enter the science department is less selective.|

Table 5. Teaching observation result.

| Type of activity | Teacher activities                                                                 |
|------------------|-------------------------------------------------------------------------------------|
| Introduction     | - The teacher gives apperception as close as possible to the lives of students, giving religious lectures related to the content |
|                  | - Motivate students about why they need to learn the content taught                 |
| Main Activity    | - The teacher starts learning with the power point media assisted lecture method   |
|                  | - The teacher displays pictures and examples of content                             |
|                  | - The teacher provides a simulation of the concepts learned                         |
|                  | - The teacher gives examples of problems to students                                 |
| Type of activity | Teacher activities |
|------------------|--------------------|
| Closing          | Summing up learning|
|                  | Give practice questions|
|                  | Close learning     |

The following are photos of learning activities observed by the author:

![Figure 2. How the teacher explains content.](image)

3.4. Conformity Analysis with Submission

Thermal equilibrium content and heat transfer are abstract content, because the physical processes that occur are microscopic so that they are not visible to the eye. Submission of this content requires a variety of special media that can clearly describe the actual physical process.

Researchers see if this content is more effectively delivered using computer-based simulations. It aims to show or simulate the actual occurrence of students. The learning done by the teacher in this study also uses simulation media to explain the concept of heat transfer. However, after the implementation of the media still left a lot of misconceptions on students. So, researchers think it is necessary to provide alternatives to simulation.

A good alternative to be used in identifying and reducing misconceptions is by changing teaching content. The type of teaching content that is in accordance with the researcher's intention to be used in the subsequent research, namely CCT (Conceptual Change Text) in the aftermath of reviewing several journal literatures found that CCT can identify misconceptions and can reduce them. [7,6,8]. To accompany the designed CCT, previous researchers often integrated it with simulation/animation, in this case we prefer to use AR (Augmented Reality).

4. Conclusions

Thus, eleventh grade students’ conception has been analyzed in misconceptions on heat transfer context such as: (1) Heat transfer is taking place while system has reached thermal equilibrium, so temperature difference still exists; (2) Objects that absorb heat more quickly, will emit heat radiation more slowly; (3) In conduction, heat flows because it is carried by moving electron of a medium; (4) In convection, the rate of convection goes faster as the water boils. One way to remediate these misconceptions is by using CCText as a teaching learning content

5. References

[1] Purdie H 2002 Conception of Learning Assessing Students Conceptions of Learning Australian Journal of Educational & Developmental Psychology Vol 2, 2002 17-32
[2] Yumusak, et al 2015 Effect of Computer-Assisted Instruction with Conceptual Change Texts on Removing the Misconception of Radioactivity Journal for the Education of Grifred Young Scientists 23-50

[3] Ozkan, G 2013 The Use of Conceptual Change Texts as Class Content in The Teaching of “Sound” in Physics Asia Pacific Forum on Science Learning and Teaching 14

[4] Samsudin, et al 2017 Alleviating Students' Misconceptions About Newton's First Law Through Comparing PDEODE*E Tasks and POE Tasks: Which is more Effective? Turkish Online Journal of Educational Technology Special Edition

[5] Anggoro, Widodo, & Suhendi 2017 Pre-service Elementary Teachers Understanding on Force and Motion In Journal of Physics: Conference Series 895 1 012151

[6] Ozkan, Gulbin 2013 The Use of Conceptual Change Texts as Class Content in The Teaching of “Sound” in Physics Asia Pacific Forum on Science Learning and Teaching 14

[7] Ozkan, et al 2015 Effect of Technology Enhanced Conceptual Change Texts on Students’ Understanding of Buoyant Force Universal Journal of Education Research

[8] Ozkan, et al 2016 Facilitating Conceptual Change in Students’ Understanding of Concepts Related to Pressure European Journal of Physics

[9] Kanli, U 2015 Using a Two-Tier Test to Analyse Students' and Teachers' Alternative Concepts in Astronomy. Science Education International, 26 2 148-165

[10] Hasan, Bagayoko D, & Kelley 1999 Misconceptions and the certainty of response index (CRI) Physics education 34 294-299

[11] Kaltakçi, Didiş 2007 Identification of Pre-Service Physics Teachers’ Misconceptions on Gravity Concept: A Study with a 3-Tier Misconception Test AIP Conference Proceedings (Vol. 899, No. 1, pp. 499-500). AIP.

[12] Arslan, Cigdemoglu, & Moseley, 2012 A three-tier diagnostic test to assess pre-service teachers’ misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain International journal of science education 34 11 1667-1686.

[13] Masykuri, Rahardjo 2018 Student certainty answering misconception question: study of Three-Tier Multiple-Choice Diagnostic Test in Acid-Based and Solubility Equilibrium Journal of Physics: Conference Series 1006 012018

[14] Suhendi, et al 2017 Effectiveness of Visual Multimedia Supported Conceptual Change Texts on Overcoming Students’ Misconception about Boiling Concept Turkish Online Journal of Educational Technology

[15] Hermita, Suhandi, Syaoedih, Samsudin, Marhadi, Sapriadil, & Wibowo 2018 Level conceptual change pre-service elementary teachers on electric current conceptions through visual multimedia supported conceptual change Journal of Physics: Conference Series 1013 012060

[16] Wibowo, Hernita, Suhandi and Costu 2017 Contribution of Virtual Microscopic Simulation (VMS) to Unveil Students' Conceptual Development and Misconceptions of Physics concepts of Heat Transfer Turkish Online Journal of Educational Technology 639-647

[17] Suherli Z 2016 Pengembangan Media Simulasi Virtual Perpindahan Kalor dan Penggunaannya dalam Pembelajaran Fisika yang Berorientasi Pengubahan Konsepsi Siswa SMA (Doctoral dissertation) Bandung: Universitas Pendidikan Indonesia